HISTORY

OF

THE MANUFACTURE OF IRON

IN ALL AGES,

AND PARTICULARLY IN THE UNITED STATES FOR
THREE HUNDRED YEARS, FROM 1585 TO 1885.

BY

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Iron breaketh in pieces and subdueth all things.—Daniel, ii. 40.

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PREFACE.

One of the most concise passages in all literature, and yet one of the most comprehensive passages, is that with which the Father of History begins his great work. "These are the researches of Herodotus of Halicarnassus, which he publishes, in the hope of thereby preserving from decay the remembrance of what men have done." In the preparation of the following pages I have constantly kept in mind the words of the great traveler and historian, and have sought to preserve from decay "the remembrance of what men have done" in the manufacture of iron in all ages, and particularly what they have done in our own country.

No historical record of the iron industry of the scope of that which is here presented has been undertaken by any of the authoritative writers upon iron and steel. Such standard works as those of Alexander, Overman, Percy, and Bauerman are more technical than historical, while the excellent history of Mr. Scrivenor was published more than forty years ago, and relates almost entirely to the iron industry of Great Britain. None of the works mentioned devote much attention to the growth of the American iron industry. Most of them, indeed, were written before our iron industry became especially noticeable for either enterprise or productiveness. The history of that industry, written from a sympathetic standpoint and with a full knowledge of details, and particularly with a knowledge of its marvelous growth in the last few decades, had yet to be written, and this service I have endeavored to perform in the present volume in connection with the history of the manufacture of iron in other countries. I have aimed especially to preserve in chrono-

logical order a record of the beginning of the iron industry in every country, and in every section of our own country, and to follow this record with a circumstantial account of the introduction into our country of all modern methods of manufacturing iron and steel. Names of persons and places, exact dates, authentic statistics, and accomplished results have been preferred to technical details, although these have not been neglected.

This history of a great industry has been compiled under circumstances which may be frankly stated. Having been honored with the task of collecting the iron and steel statistics of the United States for the census year 1880 I accompanied the official report of these statistics with the first draft of the historical details which form this volume. The historical chapters which accompanied that report were prepared from data which I had been engaged for years in collecting. The present publication embodies the results of a much fuller and more leisurely study of a most interesting and important subject.

In the collection of the materials for this volume I have been exceedingly fortunate in possessing a personal acquaintance with most of the leading actors in the wonderful development of our American iron industry during the present century, and in learning from their own lips and from their own letters many of the incidents of that development. It is the exact truth to say that, if the preparation of this history had been delayed for a few years, it could not have been written, for many of these pioneers are now dead.

It only remains for me to express my sincere thanks to all the friends who have aided me in obtaining information for the following pages, and to add that due credit is given in the text to the printed authorities which have been consulted.

PHILADELPHIA, October, 1884.

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THE MANUFACTURE OF IRON IN ALL AGES.

CHAPTER I.

THE EARLIEST USE OF IRON.

THE use of iron can be traced to the earliest ages of antiquity. Copper and bronze, or brass, may have been used at as early a period as iron, and for many centuries after their use began they undoubtedly superseded iron to a large extent, but the common theory that there was a copper or a bronze age before iron was either known or used is discredited by Old Testament history, by the literature of the ancient Greeks, and by the discoveries of modern antiquarians.

Iron was first used in Western Asia, the birthplace of the human race, and in the northern parts of Africa which are near to Asia. Tubal Cain, who was born in the seventh generation from Adam, is described in the 4th chapter of Genesis as "an instructor of every artificer in brass and iron." The Egyptians, whose existence as a nation probably dates from the second generation after Noah, and whose civilization is the most ancient of which we have any knowledge, were at an early period familiar with the use and manufacture of iron. Iron tools are mentioned by Herodotus as having been used in the construction of the pyramids. In the sepulchres at Thebes and Memphis, cities of such great antiquity that their origin is lost, butchers are represented as using tools which antiquarians decide to have been made of iron and steel. Iron sickles are also pictured in the tombs at Memphis, and at Thebes various articles of iron have been found which are preserved by the New York Historical Society and are probably three thousand years old. Thothmes the First, who is

supposed to have reigned about seventeen centuries before Christ, is said, in a long inscription at Karnak, to have received from the chiefs, tributary kings, or allied sovereigns of Lower Egypt presents of silver and gold, "bars of wrought metal, and vessels of copper, and of bronze, and of iron." From the region of Memphis he received wine, iron, lead, wrought metal, animals, etc. An expedition which the same king sent against Chadasha returned, bringing among the spoil "iron of the mountains, 40 cubes." Belzoni found an iron sickle under the feet of one of the sphinxes at Karnak, which is supposed to have been placed there at least six hundred years before Christ. A piece of iron was taken from an inner joint of the great pyramid at Gizeh in 1837. Both of these relics are in the British Museum. The reference to iron in Deuteronomy, iv. 20, apparently indicates that in the time of Moses the Egyptians were engaged in its manufacture, and that the Israelites, if they did not make iron for their taskmasters, were at least familiar with the art of manufacturing it: "But the Lord hath taken you, and brought you forth out of the iron furnace, even out of Egypt." This expression is repeated in I. Kings, viii. 51. A small piece of very pure iron was found under the obelisk which was removed in 1880 from Alexandria to New York.

The use of iron and the art of manufacturing it were introduced into the southern and western portions of Arabia at a very early day, and this may have been done by the Egyptians; it is at least established that some of their own works were located east of the Red sea. In 1873 the ruins of extensive iron works of great antiquity and of undoubted Egyptian origin were discovered near the Wells of Moses, in the Sinaitic peninsula: they are fully described by Day, in his *Prehistoric Uses of Iron and Steel.* The country which lies to the south of Egypt is supposed to have produced iron in large quantities in prehistoric times.

Iron was known to the Chaldeans, the Babylonians, and the Assyrians, who were cotemporaries of the early Egyptians. Some writers suppose that the Egyptians derived their supply of iron principally from these Asiatic neighbors and from the Arabians. Iron ornaments have been found in Chaldean ruins, and Chaldean inscriptions show that iron was known to

the most ancient inhabitants of Mesopotamia. In the ruins of Nineveh the antiquarian Layard found many articles of iron and inscriptions referring to its use. Among the articles discovered by him were iron scales of armor, from two to three inches in length. "Two or three baskets were filled with these relics." He also found "a perfect helmet of iron, inlaid with copper bands." In the British Museum there are preserved several tools of iron which were found at Nineveh by Layard, including a saw and a pick. The art of casting bronze over iron, which has only recently been introduced into modern metallurgy, was known to the Assyrians. At Babylon iron was used in the fortifications of the city just previous to its capture by Cyrus, in the sixth century before Christ. In a celebrated inscription Nebuchadnezzar declares: "With pillars and beams plated with copper and strengthened with iron I built up its gates." The huge stones of the bridge built by his daughter Nitocris were held together by bands of iron fixed in place by molten lead.

The Book of Job, which relates to a patriarchal period between Abraham and Moses, contains frequent references to iron, even to "bars of iron," "barbed irons," "the iron weapon," and the "bow of steel." In the 19th chapter and 24th verse the "iron pen," which could be used to engrave upon a rock, is mentioned. In the 20th chapter and 24th verse iron and steel are both mentioned, showing that in the time of Job the two metals were both in use: "He shall flee from the iron weapon, and the bow of steel shall strike him through." In the 28th chapter and 2d verse it is declared that "iron is taken out of the earth." Job is supposed to have lived in the northern part of Arabia, in the land of Uz, which was separated from Ur of the Chaldees, where Abraham was born, by the Euphrates. Iron ore of remarkable richness is still found between the Euphrates and the Tigris.

Moses led the children of Israel out of Egypt fifteen or sixteen hundred years before the Christian era. In the story of their wanderings iron is frequently mentioned. When the Israelites spoiled the Midianites they took from them iron and other metals; when they smote Og, the king of Bashan, they found with him an iron bedstead. Canaan, the Land of Promise, is described by Moses in Deuteronomy, viii. 9, as "a

land whose stones are iron." Iron is still made in the Lebanon mountains. In Deuteronomy, xxvii. 5, 6, and in Joshua, viii. 31, the use of iron tools in building an altar of "whole stones" to the Lord is prohibited, which shows that, not only did the Israelites in the days of Moses have a knowledge of iron tools that would cut stone, but that the Egyptians must have possessed the same knowledge. After the Israelites came into possession of Canaan iron is frequently mentioned in their history, some of the earliest references being to chariots of iron, which the Canaanites used in their wars with them, and to agricultural implements and other tools of iron, and to iron weapons of war. In the elaborate description of the armor of Goliath it is said that "his spear's head weighed six hundred shekels of iron." Axes and saws and harrows of iron are mentioned in the reign of David, and axes and hammers and tools of iron in the reign of Solomon. Solomon, in Proverbs, xxvii. 17, speaks of a use of iron which shows that knives must have been made of it in his day: "Iron sharpeneth iron; so a man sharpeneth the countenance of his friend." We read also in Ecclesiastes, x. 10: "If the iron be blunt, and he do not whet the edge, then must he put to more strength." When David, about a thousand years before Christ, made preparations for the building of the temple he "prepared iron in abundance for the nails for the doors of the gates, and for the joinings;" and in his instructions to Solomon concerning it he said that he had prepared "brass and iron without weight," and that "of the gold, the silver, and the brass, and the iron, there is no number." When Solomon came to build the temple he sent to Hiram, king of Tyre, for "a man cunning to work in gold, and in silver, and in brass, and in iron." The Phœnicians were celebrated as workers in all the metals. Isaiah speaks of harrows of iron, and in the 34th verse of the 10th chapter iron axes are clearly referred to: "And he shall cut down the thickets of the forest with iron." Jeremiah speaks of "an iron pillar." Daniel says that "iron breaketh in pieces and subdueth all things."

In Jeremiah, xv. 12, the question is asked by the prophet: "Shall iron break the northern iron and the steel?" The northern iron and steel here referred to were probably products of Chalybia, a small district of Armenia, lying on the

southeastern shore of the Black sea, the inhabitants of which, called Chalibees or Chalybians, were famous in the days of Asiatic pre-eminence for the fine quality of their iron and steel. Herodotus, in the fifth century before Christ, speaks of "the Chalybians, a people of ironworkers." They are said to have invented the art of converting iron into steel, but it is probable that, as they used magnetic sand, they made steel mainly. Latin and Greek names for steel were derived from the name of this people. From the same source we obtain the words "chalybean" and "chalybeate."

But other eastern nations doubtless made steel at as early a day as the Chalybians. In Ezekiel, xxvii. 12, the merchants of Tarshish are said to supply Tyre with iron and other metals, and in the 19th verse of the same chapter the merchants of Dan and Javan are said to supply its market with "bright iron." Tarshish is supposed to have been a city in the south of Spain, and Dan and Javan were probably cities in the south of Arabia. The name Tarshish may, however, have referred generally to the countries lying along the western coast of the Mediterranean and beyond the Pillars of Hercules. Dan and Javan may have supplied iron made in the southern part of Arabia, or they may have traded in the "bright iron," or steel, of India. The period embraced in the references quoted from Ezekiel was about six hundred years before Christ. Both Tyre and Sidon traded in all the products of the East and the West for centuries before and for some time after Ezekiel, and iron was one of the products which they supplied to their neighbors, the Israelites.

The Persians and their northern neighbors, the Medes, made iron and steel long before the Christian era, and so did the Parthians and other Scythian tribes. The Parthian arrow was first tipped with bronze, but afterwards with steel. The Parthian kings are said to have engaged with pride in the forging and sharpening of arrow-heads. Herodotus says that an "antique iron sword" was planted on the top of the mount of worship used by the Scythians. Iron is still made in Persia by primitive methods, and so also is steel, but both in small quantities.

India appears to have been acquainted with the manufacture of iron and steel from a very early period. When Alex-

ander defeated Porus, one of the Punjaub kings, in the fourth century before the Christian era, Porus gave him thirty pounds of Indian steel, or wootz. This steel, which is still made in India and Persia, was a true steel, and of a quality unsurpassed even in our day. It was and still is manufactured by a process of great simplicity, similar to that by which crucible steel is now manufactured. Ages ago Damascus, the capital of Syria, manufactured its famous swords from Indian and Persian steel. The cutlers of India now make the best of swords from native steel. Knight, in his *Mechanical Dictionary*, quotes the statement of George Thompson that he saw a man in Calcutta throw a handful of floss silk into the air which a Hindoo cut into pieces with his sabre. The people of India further appear to have become familiar at an early period in their history with processes for the manufacture of iron on a large scale which have since been lost. It is circumstantially stated that a cylindrical wrought-iron pillar is now standing at the principal gate of the ancient mosque of the Kutub, near Delhi, in India, which is about 60 feet long, 16 inches in diameter near the base, contains about 80 cubic feet of metal, and weighs probably over 17 tons. The immense proportions of this pillar are not more striking than its ornate finish. An inscription in Sanscrit is variously interpreted to assign its erection to the ninth or tenth century before the Christian era or to the early part of the fourth century after it. In the ruins of Indian temples there have been found wrought-iron beams similar in size and appearance to those used in the construction of buildings at the present time. Metallurgists are unable to understand how these large masses of iron could have been forged by a people who appear not to have possessed any of the mechanical appliances for their manufacture which are now necessary to the production of similar articles.

The period at which China first made iron is uncertain, but great antiquity is claimed for its manufacture in that mysterious country. In a Chinese record which is supposed to have been written two thousand years before Christ iron is mentioned, and in other ancient Chinese writings iron and steel are both mentioned. Pliny the Elder, writing in the first century of the Christian era, thus speaks of the iron of the

Seres, who are supposed to have been the people of China: "Howbeit, as many kinds of iron as there be, none shall match in goodness the steel that cometh from the Seres, for this commodity also, as hard ware as it is, they send and sell with their soft silks and fine furs. In a second degree of goodness may be placed the Parthian iron."

Further inquiry in these pages into the evidences of the use of iron by the oldest nations of antiquity is unnecessary. It may be assumed as susceptible of abundant proof that the knowledge of the use of iron, if not of its manufacture, was common to all the people of Asia and of Northern Africa long previous to the Christian era. The Phœnicians would carry this knowledge to their own great colony, Carthage, which was founded in the ninth century before Christ, and to all the colonies and nations inhabiting the shores of the Mediterranean. Phœnician merchants obtained iron from such distant countries as Morocco and Spain, and possibly even from India and China, as well as from nearer sources. But in time the merchants of Tyre and the "ships of Tarshish" deserted the places that long had known them; empire after empire fell in ruins; and with the fading away of Asiatic and African civilization and magnificence the manufacture and the use of iron in Asia and Africa ceased to advance. Egypt has probably not made iron for nearly two thousand years, and probably no more iron is made in all Asia to-day than was made in its borders twenty-five centuries ago, when Babylon was "the glory of kingdoms, the beauty of the Chaldees' excellency."

CHAPTER II.

THE EARLY USE OF IRON IN EUROPE.

The authentic history of the use of iron in Europe does not begin until about the period of the first Olympiad, corresponding to the year 776 before the Christian era, although Grecian poetry and the fables of the Grecian heroic age have transmitted to us many references to iron long prior to that period. Authentic Grecian history itself does not begin until the first Olympiad. About the time of Moses the Phœnicians are said to have introduced into Greece the art of working in iron and other metals. Minos, king of Crete, was indebted to them for the tools which enabled him to build his powerful fleet. In the fifteenth century before Christ the burning of the forests on Mount Ida, in Crete, is said to have accidentally communicated to the inhabitants the art of obtaining iron from native ores. This discovery enabled the Idæi Dactyli, who were priests of Cybele, to introduce the manufacture of iron and steel into Phrygia, a Greek colony in Asia Minor. So read some of the stories which have come down to us from the heroic age of Greece, all of which, like the well-known story of Vulcan and his forges on the island of Lemnos, may be wholly fabulous; but there is nothing improbable in the conclusion which may be derived from them, that they point to a very early use of iron by the Greeks. From Phœnicia certainly, and probably also from Egypt, they would be likely to derive some knowledge of its use in the mechanic arts about a thousand years before Christ. It is worthy of notice that the mythologies of both Greece and Egypt attributed the invention of the art of manufacturing iron to the gods—a fact which of itself may be regarded as establishing the great antiquity of the art in both countries.

The poems of Homer, who is supposed to have lived about 850 years before the Christian era, and therefore before the era of authentic Grecian history, make frequent mention of iron; and the art of hardening and tempering steel is fully described in the reference to the plunging of Ulysses' fire-

brand into the eye of Polyphemus—an act likened to that of the smith who "plunges the loud-hissing axe into cold water to temper it, for hence is the strength of iron." It would appear, however, from the offer by Achilles of "a mass of iron, shapeless from the forge," as a prize at the funeral games of Patroclus, that iron was not abundant in Greece at the time of the Trojan war, nor in the days of Homer himself. Troy fell in the year 1184 before the Christian era. Dr. Schliemann has found no traces of iron in its ruins. The address of Achilles to the Greeks, when offering the prize, indicates how valuable iron was to them in the heroic age.

> Stand forth, whoever will contend for this;
> And if broad fields and rich be his this mass
> Will last him many years. The man who tends
> His flocks, or guides his plough, need not be sent
> To town for iron: he will have it here.

When Pisander and Hippolochus besought Agamemnon to save their lives they offered him as ransom the "treasures" in the houses of Antimachus, their father,—"brass, gold, and well-wrought iron." Homer mentions steel axes as valuable prizes to be contended for in the Grecian games, and he also mentions steel weapons of war, although rarely. He speaks again of some iron as being bright and white, the inference being that steel is referred to. The Right Honorable William E. Gladstone, in his *Homeric Synchronisms*, says: "Iron is in Homer extremely rare and precious. He mentions nothing massive that is made of this material." Mr. Gladstone cites a number of references in Homer to iron and steel—the arrow-head of Pandaros, the dagger of Achilles, "the cutting tool of the chariot-maker for such fine work as shaping the felloe of the wheel," a knife for slaying oxen, and axes and adzes of steel.

Hesiod, who is supposed to have been cotemporary with Homer, mentions iron and some of its important qualities. He uses the phrases, "bright iron" and "black iron." Lycurgus, who lived about the time of the first Olympiad, is said to have required the Spartans to use iron as money; he "allowed nothing but bars of iron to pass in exchange for every commodity." These bars, for which iron rings or quoits were afterwards substituted, may have been made from the iron

ores which were found in abundance in Laconia, or they may have been obtained abroad; but the use of iron as a measure of value in the days of Lycurgus indicates that this metal could not then have been a rare commodity. If it had been a precious metal Lycurgus would not have enforced its use as money.

We next come to that period of Grecian history which introduces us to historical personages and historical events. The iron ores of Elba were worked by the Greeks as early as the year 700 before Christ. They called the island Æthalia, "from the blazes of the iron works." The working of the ores of this island is mentioned by Herodotus, who lived in the fifth century before Christ; by Diodorus, a Sicilian historian of the first century before Christ; and by Strabo, a Greek traveler and geographer, who lived at the beginning of the Christian era. The Phœnicians made iron on the island of Eubœa at a very early day, and the Greeks afterwards followed the same pursuit on the same island. Strabo speaks of the mines of Eubœa as being partially exhausted in his day. In Bœotia, on the mainland of Greece, iron was also made in very early times, and probably in other parts of the Grecian mainland and on the Grecian islands where iron ore is now found. On the island of Seriphos the ore is so rich that several cargoes of it were exported to the United States in 1883 and 1884. Herodotus speaks of iron heads to lances and arrows in his day. He also mentions a silver bowl inlaid with iron, the work of Glaucus the Chian, which Alyattes dedicated at Delphi about the year 560 before Christ. Chalybian steel was imported into Greece in the time of Herodotus; and in the time of Aristotle, who lived a century later, the Greeks were themselves familiar with the manufacture of steel. Sophocles, who died in the year 406 before Christ, speaks of the tempering of iron in water. The manufacture of swords of steel about this time received much attention in Greece, as it did elsewhere. The father of Demosthenes was a manufacturer of arms, and probably of steel swords. Iron and steel weapons began to displace those of bronze in most Mediterranean countries soon after the battle of Marathon, which was fought in the year 490 before Christ. When Xerxes invaded Greece, ten years after the battle of Marathon, the Assyrians

in his army carried wooden clubs "knotted with iron." The use of iron scythes as well as iron sickles was common among the Greeks about this time. Dr. Schliemann says that iron was known to the Myceneans, whose capital city, Mycenæ, was destroyed in the year 468 before Christ. Alexander, in the fourth century before Christ, is said by Pliny to have strengthened a bridge over the Euphrates, at Zeugma, with a chain made of links of iron. Daimachus, a writer who was cotemporary with Alexander, enumerates four different kinds of steel and their uses—the Chalybdic, Synopic, Lydian, and Lacedæmonian. Each kind of steel was adapted to the manufacture of particular tools. From the Chalybdic and Synopic steel were made ordinary tools; from the Lacedæmonian were made files, augers, chisels, and stone-cutting implements; and from the Lydian were made swords, razors, and surgical implements. The accounts left by this and other writers indicate great proficiency in the use of steel by the Greeks, and the possession by them of much skill in its manufacture.

A description of one of the "naval monsters" constructed by Archimedes for king Hiero, of Syracuse, about the middle of the third century before the Christian era, shows the great extent to which the use of iron had then been carried by the Greeks. "To each of the three masts was attached a couple of engines which darted iron bars and masses of lead against the enemy. The sides of the ship bristled with iron spikes, designed to protect it against boarding; and on all sides were likewise grapples which could be flung by machines into the galleys of the foe. The ship was supplied with twelve anchors, of which four were of wood and eight of iron."

According to accepted chronology, Rome was founded in the year 753 before the Christian era. It reached the culmination of its power about the end of the first century of that era. The period from its foundation to the beginning of its decline embraced about nine hundred years. During the first part of this period Rome was favored with the experience of older nations in the use and manufacture of iron, and during the last part of it she greatly contributed by her energy and progressive spirit to extend its use and to increase its production. The Greeks were the great teachers of the Romans in all the arts, including metallurgy; but the Etruscans, who

were the near neighbors of the Romans, and whom they in time supplanted, also contributed greatly to their knowledge of the arts of ancient civilization. The Etruscans, however, owed their civilization in large part to the Tyrrhenian Greeks, with whom they coalesced centuries before Rome was founded. Etruria was largely devoted to commerce, and among the countries with which it traded were Phœnicia and Carthage, as well as Greece and its colonies. From all these countries Etruscan civilization was invigorated and diversified, and Rome in its early days enjoyed the benefit of this invigoration and diversification. That it early acquired from the Etruscans a knowledge of the use and manufacture of iron can easily be imagined, and subsequent direct contact with Grecian colonies and with Greece itself would extend this knowledge. The island of Elba lay off the Etruscan coast, and, as has been already stated, its iron ores were extensively used by the Greeks about the time when Rome was founded. Its mines were also worked by the Etruscans, and its ores were smelted both on the island and on the mainland. They were also taken to other countries to be converted into iron. After a lapse of twenty-five centuries the iron ores of this celebrated island are still exported, many cargoes finding their way to the United States. The Romans would also obtain iron from the islands of Corsica and Sardinia, but chiefly from the former. This island was occupied by the Ligurians and the Etruscans about the time of the founding of Rome, and by the Etruscans for centuries afterwards. The Carthaginians succeeded the Etruscans, and the Romans the Carthaginians. Iron was made in Corsica from the earliest times, and is still made in small quantities. The island has given its name to the Corsican forge, which is yet in use. A few years ago ten of these forges were in operation in Corsica, and they were probably almost identical in character with those which were used on the island when Rome was founded.

Iron is frequently mentioned in the early history of Rome. A war between the Romans and the Etruscans, the latter being led by their king, Porsenna, occurred in the year 507 before Christ, and among the conditions of peace exacted by the victorious Etruscan king was one which prohibited the Romans from using iron except for agricultural purposes. In

the year 390 before Christ, when Rome was about to be ransomed from the Gauls, under Brennus, by a large payment of gold, Camillus, the Roman dictator, demurred, and declared that Rome should be ransomed with iron and not with gold, and that his sword alone should purchase peace. Another notable mention of iron in the early history of Rome occurs in the account of the defeat of the Carthaginian fleet in the first Punic war. The consul Duilius took command of the hastily-constructed Roman fleet, and upon encountering the Carthaginian fleet he connected his ships with those of the enemy by means of grappling-irons, through which, and the superior prowess of the Romans, he gained for Rome, in the year 260 before Christ, its first naval triumph. The Etruscan town of Pupluna is said to have furnished Scipio with iron in the second Punic war, and it is stated that many thousand tons of scoria are now lying on the beach close to its site.

Some of the swords and javelins of the Romans were made of iron or steel in the fourth century before the Christian era, but their agricultural implements, as has been shown in the reference to Etruria, were made of iron at an earlier period. The Roman battering-ram, which was borrowed from the Greeks, had a head of iron, and iron rings were placed around its beam. The Romans used this engine of war at the siege of Syracuse, in the year 212 before Christ. Prior to this time iron and steel tools were in common use among the carpenters, masons, shipwrights, and other tradesmen of Rome. At the beginning of the Christian era iron was in general use throughout the Roman empire, the supply being derived from many countries which were subject to its sway. In the Acts of the Apostles, xii. 10, is a statement which indicates that iron was used at this period for architectural purposes and in public works: "When they were past the first and the second ward they came unto the iron gate that leadeth unto the city." Iron was, however, used especially for tools, agricultural implements, and weapons of offense and defense. Pliny says that "iron ores are to be found almost everywhere." He describes in detail the various uses to which iron was applied in his day, and places it at the head of all the metals. Vestiges of iron used by the Romans in the first century after Christ

have been found in the ruins of the Coliseum, which was built by the emperor Vespasian. This iron was used as clamps to bind together the stones of that remarkable structure. Iron has also been found in the ruins of Pompeii, which was destroyed about the time the Coliseum was built.

In the northern part of Italy, just south of the Alps, corresponding to Piedmont and Lombardy of the present day, iron was made by the Romans in the first and second centuries before the Christian era. Pliny speaks of the excellence of the water at Comum, now Como, for tempering iron, although he says that iron ores were not found there. This part of Italy and the island of Elba have continued to make small quantities of iron ever since the days of Pliny, the business being confined mainly to small forges. In the manufacture of ornamental smithwork of iron Italy was very prominent in the middle ages, and for the manufacture of arms and armor its great city of Milan was widely celebrated from the end of the fourteenth to the end of the sixteenth century.

Among the provinces which contributed largely to the Roman supply of iron was Noricum, corresponding to Styria and Carinthia in Austria. Both Pliny and Ovid, who lived at the beginning of the Christian era, speak of Norican iron as being of superior quality, and it is certain that *ferrum noricum* was celebrated throughout Italy before their day. The best of swords were made from it in the reign of Augustus: Horace speaks of them. The spathic ores of Styria and Carinthia are still held in high favor; and the supply of ore, especially in the famous iron mountains of Erzberg and Hüttenberg, shows no signs of exhaustion at the end of twenty centuries of almost constant use. Iron is still made in these provinces of Austria in small forges which are almost as primitive in character as those used by their ancient Celtic inhabitants. Celtic and Roman implements and medals, including a coin of the emperor Nerva, who lived in the first century of the Christian era, have been found in mounds of slag in the vicinity of Carinthian iron mines.

Cotemporaneously with the working of the Norican iron mines by the Celts, the Quadi, who inhabited the province of Moravia, lying north of Noricum, also made iron. The geographer Ptolemy, who lived in the second century of the Chris-

tian era, makes mention of the Quadi as ironworkers. Iron was also made in Hungary at the beginning of the Christian era. A late writer, Mr. Kerpely, of Buda-Pesth, says: "Even in the time of the Romans, and in the first century of our era, the excellent iron ores of Hungary were mined not far from the famous Trajan road and the Roman colonies lying near thereto." Great antiquity is also claimed for the iron industry of that vast country which was known to the Romans as Sarmatia, but is now called Russia in Europe. The nomadic Scythians would doubtless carry the art of ironmaking to the Ural mountains, where iron ore was and still is abundant. One of the Greek poets calls Scythia "the mother of iron"—Scythia comprising the countries lying north, east, and south of the Caspian sea.

The Phœnicians founded colonies in France and Spain prior to the sixth century before Christ. They had settlements in Southern Gaul, on the Garonne and Rhone. The ancient city of Massilia, now Marseilles, is supposed to occupy the site of a Phœnician trading-post which fell into the possession of the Phocæan Greeks about the period we have mentioned, who gave to it great commercial and manufacturing importance. The Greeks also planted other colonies in Southern France. The city of Tartessus, or Tarshish, is supposed to have been one of the Phœnician settlements in the south of Spain; the city of Gades, or Cadiz, was another. Tartessus stood between the two arms of the Guadalquivir; but in the time of Strabo, who died about the year 25 of the Christian era, it had ceased to exist; Gades was its near neighbor, and still exists. It is probable that the Phœnicians introduced the manufacture of iron among the native inhabitants of France and Spain; the Celtiberians of the latter country were certainly active in the mining and working of metals several hundred years before the Christian era, and enjoyed an extensive trade in metals with Tyre and Carthage.

Under Grecian influence, which succeeded that of the Phœnicians in Spain, the Celtiberians, who inhabited the central and northeastern parts of the country, continued to make iron, and to this was joined the manufacture of steel. The famous forges of Aragon and Catalonia were active during the Grecian occupation of Spain. The Carthaginians for a brief time suc-

ceeded the Greeks in Spain, and about two centuries before the Christian era the Romans succeeded the Carthaginians. The Romans greatly extended the arts of their advanced civilization among the native inhabitants. They gave special encouragement to the manufacture of iron and steel, although in justice to the Celtiberians it must be said that their metallurgical skill was at least equal to that of the Romans. Polybius, a Greek historian who flourished in the second century before Christ, says that the helmet and armor of the Roman soldier were of bronze, but that the sword was a cut-and-thrust blade of Spanish steel. At the battle of Cannæ, in the year 216 before Christ, the Romans had learned from the Carthaginians at very great cost the value of the Spanish sword. Livy has recorded the fines which were imposed by Cato the Censor on the Celtiberian iron works after the Roman war with Spain in the year 194 before Christ. About the time these fines were imposed the town of Bilbilis, near the present Moorish-built town of Calatayud, in Aragon, and the little river Salo were celebrated as the centre of the iron district of Celtiberia. The water of the Salo was supposed to possess special qualities for the tempering of steel. The same excellence was attributed to other streams in Spain and in some other countries. Diodorus speaks of the excellent two-edged swords, "exactly tempered with steel," and of other arms which the Celtiberians in Aragon manufactured from rods of iron which had been rusted in the ground "to eat out all the weaker particles of the metal, and leave only the strongest and purest." He says that the swords which were manufactured from these rods "are so keen that there is no helmet or shield which can not be cut through by them." Plutarch, who died about the year 140 of the Christian era, gives the same account of the Celtiberian method of purifying iron. Pliny speaks of the excellent iron of Bilbilis and Turiasso, the latter a town in Tarragona, and of an extensive mountain of iron upon the coast of Biscay, probably Somorrostro. Iron ore from the coast of Biscay is now exported in large quantities to Great Britain, Germany, the United States, and other countries. Toledo has been famous since the Roman occupation of Spain for its manufacture of swords, but this industry existed at Toledo before the appearance of the

Romans. The town was captured by them in the year 192 before Christ. The Roman army from that time forward was provided with steel swords from Toledo and other places in Spain. The manufacture of Toledo blades probably attained its greatest development in the fifteenth and sixteenth centuries. The business still continues in a restricted way. A certain degree of mystery has always surrounded the manufacture of these swords, and the same may be said of the manufacture in ancient times of the equally celebrated Damascus blades. Swords are still made at Damascus, but they are of inferior quality.

The iron industry of Spain was the first in the world for many hundred years after the Romans obtained a foothold in the country, surviving the downfall of the Roman power in the Peninsula, and flourishing under the subsequent rule of the Visigoths. This distinction was strengthened when the Moors became masters of the greater part of Spain, in the beginning of the eighth century of the Christian era. They stimulated the further development of the iron manufacture in the districts subject to their sway. At the same time the native inhabitants who had successfully resisted the Moorish arms continued to push their small Catalan forges still farther into the Pyrenees and along the coast of Biscay, lighting up the forests in every direction. So prominent did the iron industry of Spain become that its ironworkers were sought for by other countries, and on the French side of the Pyrenees, and in the mountains of Germany, and along the Rhine they set up many of their small forges. The Catalan forge, which received its name from Catalonia, has been introduced into every civilized country of modern times that produces iron, and it still exists in almost its original simplicity in the mountains of both Spain and France, and in the Southern States of our own country. To-day, however, whatever prominence the iron industry of Spain possesses is derived from the large shipments of its iron ores to more enterprising countries.

France did not at an early period in its history make the same progress in the manufacture of iron that has been recorded of Spain, partly because it did not receive the same outside attention which made Spain a centre successively of Phœnician, Grecian, Carthaginian, Roman, Gothic, and Moor-

ish civilization, but partly also because it did not possess as rich iron ores as those of Spain. It may be said, however, that iron weapons were well known to the Gauls who confronted the Romans hundreds of years before the Christian era, and to their successors who opposed the armies of Julius Cæsar, who refers frequently to their use of iron. In speaking of the Veneti, who inhabited the southern part of Brittany, he makes the remarkable statement that the anchors for their ships were fastened to them with iron chains instead of cables. He also says that the benches of the ships were fastened with iron spikes of the thickness of a man's thumb. This circumstantial statement denotes great familiarity with the use of iron by the Veneti. In describing the siege of Avaricum, the modern Bourges, a fortified town of the Bituriges, Cæsar says that "there are in their territories extensive iron mines, and consequently every description of mining operations is known and practiced by them."

For hundreds of years after Cæsar's time only faint glimpses are furnished us of an iron industry in France. During this period it was doubtless wholly confined to Catalan forges. In the remains of a celebrated bridge erected by Charlemagne over the Rhine, at Mayence, in the latter part of the eighth century, and which have but recently been removed, iron in a good state of preservation, "being covered by only a thin layer of rust," has been found riveted to the wood-work. *Stücköfen*, or high bloomaries, were in use in Alsatia and in Burgundy in the tenth century. When William the Norman invaded England in 1066 he was accompanied by many smiths who were armorers and horse-shoers, and therefore skilled workers in iron. The modern blast furnace is supposed to have originated in the Rhine provinces about the beginning of the fourteenth century, but whether in France, or Germany, or Belgium is not clear. A hundred years later, in 1409, there was a blast furnace in the valley of Massevaux, in France, and it is claimed by Landrin that France had many blast furnaces about 1450.

Iron was made by the Belgæ as early as the time of Julius Cæsar, and possibly at an earlier date. Heaps of iron cinder, which antiquarians decide to be as old at least as the Roman occupation of Gallia Belgica, have recently been found on the

tops of ferruginous hillocks in the provinces of Brabant and Antwerp, and in these cinder heaps flint arrow-heads and fragments of coarse pottery, characteristic of the earliest dawn of civilization, have been discovered. During the Roman occupation of the country iron was produced in many places in Belgium, a fact which is attested by heaps of cinder or slag which yet exist and are found in association with Roman relics. It has been supposed that the iron which was made in Belgium at this period was produced in low bloomaries without an artificial blast. It is, perhaps, a more reasonable supposition that the Romans found this primitive method in use among the Belgians, and that they introduced an artificial blast by means of a leather bellows. We do not again hear of the Belgian iron industry until the tenth century, when high bloomaries, or wolf furnaces, otherwise *stücköfen*, were in operation in the valley of the Meuse. We are informed that "iron was made to perfection in the Netherlands" in the twelfth century. In the fourteenth century high furnaces, or *flussöfen*, were in existence in Belgium. In 1340 a furnace of this description was built at Marche les Dames, near Namur, to which special privileges were granted in 1345 by William, count of Namur. Franquoy refers to documentary evidence that there were *hauts fourneaux*, or blast furnaces, at Vennes and Grivegnée, near Liége, in Belgium, before 1400. All these furnaces were true blast furnaces, producing cast iron. In 1560 there were in operation in Belgium, according to M. Déby, 35 blast furnaces and 85 forges. In 1613 permission was granted to two armorers of Maestricht to convert iron into steel.

Near Saarbrücken, in Rhenish Prussia, where the first battle between the French and the Germans was fought in the war of 1870, iron is said to have been made in the days of Roman ascendency, but the Germans do not appear during this period to have been as familiar with its manufacture as their neighbors. Polybius, however, states that the Teutons and the Cimbri, from Northwestern Germany, who invaded Italy and Gaul near the close of the second century before Christ, "were already familiar with iron, and possessed weapons of that metal." Tacitus informs us that "iron does not abound in Germany, if we may judge from the weapons in

general use. Swords and large lances are seldom seen. The soldier grasps his javelin, or, as it is called in their language, his *fram*, an instrument tipped with a short and narrow piece of iron, sharply pointed, and so commodious that, as occasion requires, he can manage it in close engagement or in distant combat." He further says that the use of iron was unknown to the Æstyans, who inhabited the northern part of Germany lying upon the Baltic; "their general weapon was the club." The Gothinians are described by Tacitus as a people who "submit to the drudgery of digging iron in mines" for the Quadi, who were their neighbors. Ernest, the German editor, says the Gothinians had iron of their own, and did not make use of it to assert their liberty. Tacitus wrote his *Treatise on Germany* about the close of the first century of the Christian era. From this time forward the condition of the German iron industry is enveloped in obscurity until the eighth century, when we hear of iron works, probably wolf furnaces, or *stücköfen*, in the district of the river Lahn, in Nassau, where iron of great celebrity was made by a guild of "forest smiths" in 780. We are informed by Maw and Dredge, in their report on the iron exhibits at the Vienna Exhibition of 1873, that "they had their special privileges, kept an iron mart at Wetzlar, and sent their products regularly to the great annual fairs at Frankfort-on-the-Main. This iron industry was especially flourishing during the thirteenth, fourteenth, and fifteenth centuries." During the eighth century we hear also of the iron industry of the principality of Siegen. There was a steel forge at the town of Siegen in 1288 which had been in existence before the eleventh century. The iron industry of the principality was very active during the middle ages. About the middle of the thirteenth century *stücköfen* were in use in Siegen. Percy, in his *Metallurgy of Iron and Steel*, says that at the beginning of the fifteenth century pig iron was made in Siegen in *blauöfen*. Iron was made in Saxony as early as the eighth century. Alexander, in his excellent *Report on the Manufacture of Iron*, made to the Governor of Maryland in 1840, informs us that the *flussofen* was introduced into Saxony in 1550, and that the wooden bellows was invented about this time by Hans Lobsinger, an organist of Nuremberg. Iron was made in the Hartz mountains in the eighth century. In

the Thuringian mountains wolf furnaces and bloomaries were in existence in the tenth century, and blast furnaces in the fourteenth century. Alexander states that in the latter half of the sixteenth century there was a furnace in these mountains 24 feet high and 6 feet wide at the boshes, built by Hanssien, a Voigtlander. In 1377 cast-iron guns were made near Erfurt, in Thuringia. In the fifteenth century pots, plates, balls, etc., of iron were cast at the celebrated Ilsenberg foundry in Germany. Stoves are said to have been cast for the first time in 1490, in Alsace.

Recurring to the iron industry of Austria, Alexander says that the mines of Styria were "opened again" in 712. It appears probable that wolf furnaces were in use in Styria, Carinthia, and Carniola as early as the eighth century, which appears to be the epoch of their introduction in most European countries. The first blast furnace in the Alps provinces was, however, introduced very much later than in Belgium or on the Rhine—the first in Carinthia being built in 1567, at Urtl; the first in Styria in 1760, at Eisenerz; and the first in Carniola in the early part of the present century. Iron was made in Bohemia and Silesia at an early period. "The Bohemian chronicler, Hajek, of Liboschan, mentions that iron works existed in 677, near Schasslau." Heaps of cinder and remains of wolf furnaces and ore bloomaries are numerous in Bohemia. In 1365 bloomaries were in use in Upper Silesia. Mr. Kerpely says that written descriptions are extant of the working of iron mines in Upper Hungary in 1326 and 1408. Iron slag has been discovered in Hungary at a depth of about one foot from the surface of the ground, and in the midst of beautiful vineyards. It is probable that iron had been continuously made in Hungary and in the Austrian provinces in the period intervening between the dates above mentioned and the early operations in Noricum, Moravia, and Hungary which have already been referred to.

The iron industry of Sweden had an existence as early at least as the thirteenth century. A Swedish historian says that the oldest iron mine in Sweden is probably Norberg, in Westmanland, on the southern borders of Dalecarlia. There are documents still in existence, dated July 29, 1303, signed by Thorkel Knutson, the royal marshal, in which Norberg is

mentioned as an iron mine. To the miners of Norberg, also, exclusive privileges were granted by king Magnus Ericsson in 1354. It is probable, however, that the manufacture of iron in both Sweden and Norway antedates the time of the vikings in the eighth and ninth centuries of the Christian era, as the remains of their vessels which have been discovered have been found to contain iron. It may also be said that, as iron was made in other European countries before this period, there is no good reason to doubt that it was also made in Sweden and Norway. At Taplow, on the Thames, in England, not far from Windsor Castle, the tomb of a Norse viking of undoubted identity was opened in 1883, and in it were found, among other articles, a rusted iron sword which fell into pieces when removed; an iron knife, the iron socket of a spear, an iron ring strengthening the inside of a bronze shield, and another iron ring strengthening the bottom of a bronze bucket. In 1488 the celebrated mines of Dannemora were opened, and in 1614 Gustavus Adolphus encouraged the immigration of German furnacemen into Sweden. The celebrated iron works at Finspong were established in 1641 by Louis de Gier, from Liége, as a cannon foundry. The Walloon refining process, which takes its name from the Walloons, who were inhabitants of Flanders, was introduced into Sweden from Flanders in the time of Charles the Twelfth, who reigned from 1697 to 1718. Percy states that the osmund furnace, which was a modification of the *stückofen*, was formerly very common in Sweden. Overman, in his *Manufacture of Iron*, says that this furnace was introduced into Sweden from Germany.

The iron industry of Russia dates historically from 1569, in which year, as recorded by Scrivenor, in his valuable *History of the Iron Trade*, published in 1841, the English "obtained the privilege of seeking for and smelting iron ore, on condition that they should teach the Russians the art of working this metal." The first historical iron works in Russia, however, were established long afterwards, according to the same author, in the reign of the czar Alexy Michaelovitch, about sixty miles from Moscow, and were the only ones in Russia prior to the reign of Peter the Great, who is said to have worked in them before he set out, in 1697, on his first journey

into foreign countries. It is not known when the celebrated Russia sheet iron was first made; it is not mentioned in a circumstantial enumeration of the iron manufactures of Russia about 1798. There is reason to believe that the Russians were skilled ironworkers and metallurgists long before the historic period mentioned by Scrivenor. The bells of Moscow, (not made of iron, however,) have been famous for hundreds of years.

The use of iron in a limited way was known to the Britons before the invasion of England by Julius Cæsar in the year 55 before Christ. The Phœnicians, who traded with the Britons probably as early as the year 600 before Christ, may be supposed to have introduced among this barbarous people the use of iron, but we have no proof that they instructed them in its manufacture. The Greeks and Carthaginians succeeded the Phœnicians in trading with the Britons, but there is no evidence that they taught them the art of making iron. They, as well as the Phœnicians, probably took iron into Britain in exchange for tin and other native products. Cæsar, in his *Commentaries*, says of the Britons who opposed his occupation of the island that "they use either brass or iron rings, determined at a certain weight, as their money. Tin is produced in the midland regions; in the maritime, iron; but the quantity of it is small: they employ brass, which is imported." This quotation from Cæsar would appear to establish the fact that iron was a precious metal in Britain at the time of his invasion; at least it would seem to show that it was not in common use, and could not have been used as an article of export. Cæsar nowhere mentions the use of iron weapons of war by the Britons. It is worthy of mention that the Belgæ had passed over into Britain before Cæsar's time and made settlements upon its coast, and whatever arts they possessed they would of course take with them. It can not be proved that the Belgæ made iron in their own country before Cæsar's invasion of it; if it could be shown that they did it might safely be assumed that they would introduce their methods of manufacture into Britain. Cæsar says that a small quantity of iron was made in the maritime regions of the island, and this the Belgæ may have made.

CHAPTER III.

THE GROWTH OF THE BRITISH IRON INDUSTRY.

IF THE manufacture of iron by the Britons prior to the Roman invasion is enveloped in obscurity and even in doubt, there can be no doubt that iron was made in considerable quantities during the Roman occupation of Britain, which nominally extended from about the middle of the first century of the Christian era to the year 411. The Romans, it may here be remarked, were never themselves prominent as iron manufacturers in any country occupied by them; but, knowing the value of iron, they encouraged its manufacture wherever their arms were borne and the necessary conditions existed. The remains of iron works which were in existence and were operated during their stay in Britain are still pointed out. Dismissing all speculation concerning the origin of the first iron works in Britain, the remains of some of these works may well receive attention. They relate to a most interesting period in the history of the British iron trade.

Large heaps of iron scoria, or cinder, as old as the Roman era, have been discovered in the Wealds of Kent and Sussex, in the hills of Somerset, and in the Forest of Dean in Gloucester; also at Bierley, a few miles from Bradford in Yorkshire, and in the neighborhood of Leeds in the same county. There is also evidence that iron was made under the Romans in the counties of Northumberland, Surrey, Glamorgan, Monmouth, Hereford, and Worcester. Except Bierley, Leeds, and Northumberland, all the places and counties named above as having produced iron lie in the southeastern or southwestern parts of England, or within the ancient boundaries of South Wales, "the country of the Silures." Next to Cornwall, where tin was obtained by the Phœnicians and their successors, these southern portions of the country would be most likely to be visited and influenced by foreigners before the Roman invasion. Cæsar described the island of Britain as being shaped like a triangle, with one of its sides looking toward Gaul: "One angle of this side is in Kent, whither almost all

ships from Gaul are directed." The cinder mentioned has been found almost invariably in connection with Roman coins, pottery, and altars. A coin of Antoninus Pius, who lived in the second century after Christ, was found in the Forest of Dean in 1762, together with a piece of fine pottery. Coins of other Roman emperors have been found in the cinder heaps of the Forest of Dean. In the cinder beds of Beauport, between Hastings and Battle, in Sussex, a bronze coin of Trajan has been found, and one of Adrian. These emperors lived in the first and second centuries after Christ. Coins found in the cinder heaps of Maresfield, not far from Uckfield, have dates ranging from Nero to Diocletian, or from the year 54 to the year 286 after Christ. In the cinder mounds of Sussex many specimens of pottery have been discovered, including black and red Samian ware. On one of these, the base of a *patera*, is the potter's mark, "Albvciani." One relic consisted of a bronze *ligula*, very thin and elastic, more than four inches long, in good preservation, and having an elegantly shaped bowl. Altars erected to Jupiter Dolichenus, the protector of iron works, have been discovered in various places in association with the remains of such works.

Much of the cinder has been found on the tops of hills or mounds, a circumstance which has led to the belief that bellows were not employed in producing a blast, but that the wind was relied upon to produce a draft sufficient to smelt the ore in crude bloomaries, some of which were mere excavations, with covered channels leading to the hillside in the direction of the prevailing winds. This primitive method of making iron is that which appears to have prevailed in Belgica at the same time. It is a curious fact that bloomaries of similar form and adaptation were in use in Derbyshire, for smelting lead, as late as the seventeenth century. Scrivenor mentions that similar furnaces were used by the Peruvians to smelt the silver ore of their country before the arrival of the Spaniards. Other bloomaries in Britain are supposed by Fairbairn and other writers to have been simple conical structures, with small openings below for the admission of air, and erected on high grounds that the wind might assist combustion. A still simpler method is supposed to have consisted in placing ore and wood or charcoal in alternate layers in ele-

vated positions, or even in the low lands. The cinder found in England and Wales was very rich in iron; in the Forest of Dean it was so rich and so abundant that for many years after its discovery, in the sixteenth century, several small charcoal furnaces were engaged in smelting it.

In M. A. Lower's *Contributions to Literature* will be found an interesting account of the discovery of Roman relics in the cinder-beds of the parish of Maresfield, in Sussex, by the Rev. Edward Turner, in 1844. This is followed by Mr. Lower with other proofs of the manufacture of iron in Sussex by the Romans. Recent researches by Mr. James Rock, of Hastings, in Sussex, throw much new light on the Roman and early British methods of manufacturing iron. Cinder beds, or cinder heaps, were formerly very numerous in East Sussex, and many of them still exist. The neighborhood of Hastings appears to have been a great centre of the iron industry "from the earliest times." The cinder heaps yet remaining are large enough to be quarried, and contain many thousand tons of scoria, some of the heaps having large oak trees growing upon their summits.

It was stated in 1681, by Andrew Yarranton, in the second part of *England's Improvements by Sea and Land*, that "within 100 yards of the walls of the city of Worcester there was dug up one of the hearths of the Roman foot-blasts, it being then firm and in order, and was 7 foot deep in the earth." The foot-blast here referred to must have been a leather bellows, with which the Romans and their Mediterranean neighbors were certainly acquainted. There is nothing improbable in the supposition that the Romans while in Britain used both the wind-bloomaries and the foot-blasts.

Strabo mentions the exportation of iron from Britain in his day. This was before the Romans had subdued the Britons, but after the influence of Roman civilization had been felt in the island. The emperor Adrian landed in Britain in the year 120, and in the following year there was established at Bath, in Wiltshire, a Roman military forge, or *fabrica*, for the manufacture of iron arms. This forge was close to the bloomaries in Somerset and the Forest of Dean, from which it was supplied with iron. That the manufacture of iron at this time and for some time subsequently was almost wholly con-

fined to the southern parts of England seems probable from a passage in Herodian, quoted by Smiles in his *Industrial Biography*, who says of the British pursued by the emperor Severus, in the year 208, through the fens and marshes of the east coast, that "they wore iron hoops round their middles and their necks, esteeming them as ornaments and tokens of riches, in like manner as other barbarous people then esteemed ornaments of silver and gold."

Percy quotes from the London *Times* an account of the opening of some prehistoric remains in the Cheviot hills in 1861 and 1862, which revealed various evidences of the rude civilization of the early Celtic, or British, inhabitants, including pieces of iron slag. These remains are assigned by the *Times* to the Roman period of British history, but they may belong to a later period.

The Anglo-Saxons, who succeeded the Romans in Britain in the early part of the fifth century, used iron tools and weapons of war, and it is a reasonable supposition that they manufactured all the iron that was required for these purposes; but their enterprise as iron manufacturers probably extended but little further, although Bede speaks of the importance of the iron industry in his day, the beginning of the eighth century. The Anglo-Saxon monks frequently engaged in the manufacture of iron. Saint Dunstan, who lived in the tenth century, is said to have had a forge in his bedroom, and to have been a skilled blacksmith and metallurgist. One of the last of the Anglo-Saxon kings was Edmund Ironsides. During the ascendency of the Danes, and afterwards down to the accession of William the Conqueror in 1066, iron was made in the Forest of Dean and elsewhere, but in limited quantities. In *Doomsday-Book* mention is made of iron works in the counties of Somerset, Hereford, Gloucester, Cheshire, and Lincoln. In the eleventh century the Anglo-Saxon plow consisted of a wooden wedge covered with straps of iron; to this the Normans added the coulter. The shipbuilders of Edward the Confessor, the last king of the Anglo-Saxons prior to Harold who lost the battle of Hastings, obtained supplies of bolts and bars of iron from the city of Gloucester. The antiquarian Camden states that "in and before the reign of William the Conqueror the chief trade of the city of Gloucester was the forging of

iron; and it is mentioned in *Doomsday-Book* that there was scarcely any other tribute required from that city by the king than certain *dicars* of iron and iron bars for the use of the royal navy. The quantity required was thirty-six *dicars* of iron; a *dicar* containing ten bars and one hundred iron rods for nails or bolts." Giraldis Cambrensis, who lived in the twelfth century, speaks of "the noble Forest of Dean, by which Gloucester was amply supplied with iron and venison." Nicholls, in *The Forest of Dean*, says that in the time of Edward the First, in the early part of the thirteenth century, the Free Miners of the Forest "applied for and obtained their 'customes and franchises,' which were granted, as the record of them declares, 'time out of mind.'" In 1282, according to Nicholls, there were "upward of seventy-two" *forgeæ errantes*, or movable forges, in the Forest, each of which paid a license of 7s. a year to the crown. Scrivenor states that during the period from the Conquest to the death of John, in 1216, iron and steel were imported into Britain from Germany and other countries, the domestic supply being insufficient. The Normans, however, contributed much to develop English iron and other resources. Green, in his *History of the English People*, says that one immediate result of the Conquest was a great immigration into England from the Continent. "A peaceful invasion of the industrial and trading classes of Normandy followed quick on the conquest of the Norman soldiery." In 1266 and subsequently we hear of iron works in Sussex which were not mentioned in *Doomsday-Book*.

Still the English iron industry made but slow progress. It is mentioned by Scrivenor that there were but few iron mines in the north of England in the thirteenth and fourteenth centuries, and that, in the tenth year of the reign of Edward the Second, in 1317, iron was so scarce in that section and in Scotland that the Scots, "in a predatory expedition which they made in that year, met with no iron worth their notice until they came to Furness, in Lancashire, where they seized all the manufactured iron they could find, and carried it off with the greatest joy, though so heavy of carriage, and preferred it to all other plunder." The Scots at this time were in great need of iron, which they did not produce, but for which they were wholly dependent on the Continent and on

the favor or ill fortune of England. Alexander says that there were iron works at Kimberworth, in Yorkshire, in 1160, and Smiles gives an extract from a contract for supplying wood and ore for iron "blomes" at Kirskill, near Otley, in Yorkshire, in 1352. A recent writer, Mr. H. A. Fletcher, says that "the earliest record which has been found of iron-ore mining in Cumberland seems to be the grant of the forge at Winefel to the monks of Holm Cultram Abbey, in the twelfth century, which also included a mine at Egremont, by inference of iron, being in connection with a forge; and Thomas de Multon confirms a gift to the same abbey *de quartuor duodenis minæ ferri in Coupland.*"

Scrivenor mentions one art related to the manufacture of iron which flourished in England from William to John, if the manufacture itself did not. The art of making defensive armor was brought to such perfection during the period mentioned that "a knight completely armed was almost invulnerable." The history of the Crusades shows that the English were then very proficient in the manufacture of both arms and armor, as were the Turks and other Asiatic tribes who resisted them. Smiles says that it was the knowledge of the art of forging iron which laid the foundation of the Turkish empire. By means of this art the Turks made the arms which first secured their own freedom and then enabled them to extend their power. Concerning the quality of the swords used by the English and by their Infidel opponents Knight quotes from Sir Walter Scott the following incident: "Scott, in the *Tales of the Crusaders*, describes a meeting between Richard Cœur de Lion and Saladin. Saladin asks Richard to show him the strength for which he is famous, and the Norman monarch responds by severing a bar of iron which lies on the floor of his tent. Saladin says, 'I can not do that,' but he takes a down pillow from the sofa, and, drawing his keen blade across it, it falls in two pieces. Richard says: 'This is the black art; it is magic; it is the Devil; you can not cut that which has no resistance.' And Saladin, to show him that such is not the case, takes from his shoulders a scarf which is so light that it almost floats in the air, and, tossing it up, severs it before it can descend."

Edward the Third, who reigned from 1327 to 1377, did

much to advance the manufacturing industries of England. He protected domestic manufactures by legislation which restricted the importation of foreign goods, and he encouraged the immigration into England of skilled workmen from the Continent. The use of iron was greatly extended in his reign, and its manufacture was active in Kent and Sussex and in the Forest of Dean. Nevertheless the domestic supply still did not meet the wants of the people. Scrivenor says: "By an act passed in the twenty-eighth year of Edward the Third no iron manufactured in England, and also no iron imported and sold, could be carried out of the country, under the penalty of forfeiting double the quantity to the king; and the magistrates were empowered to regulate the selling price and to punish those who sold at too dear a rate, according to the extent of the transaction." This act appears to have remained in force long after Edward's death. Smiles quotes from Parker's *English Home* the statement that in the reign of this king the pots, spits, and frying-pan of the royal kitchen were classed among the king's jewels.

The methods of manufacturing iron which were followed in England in the thirteenth and fourteenth centuries were still of a slow and restricted character, although very greatly advanced beyond those which existed in the days of the Romans. The English were yet mainly devoted to agriculture, but were not even good farmers, their implements of husbandry and their methods of cultivating the soil being equally rude. Wool was their great staple, and this was largely exported to the Continent, where it was manufactured into finer fabrics than the English were capable of producing. Iron was often scarce and dear, because the domestic supply was insufficient. The iron industry on the Continent was at this period in a much more advanced stage of development, and most of the Continental iron was also of a better quality than the English iron.

Professor James E. Thorold Rogers, in his *History of Agriculture and Prices in England*, gives many interesting details concerning the iron industry of England in the thirteenth and fourteenth centuries. Iron was made at this time at Tendale, in Cumberland; at or near the city of Gloucester; and in Kent and Sussex. It was doubtless made in many other

places. Steel is frequently mentioned, the first reference to it being in 1267. It is not quite clear that all the steel used in England during the period under consideration was imported, but most of it certainly was. Much of the iron used was imported, frequent mention being made of Spanish and osemond iron. Osemond steel is also frequently mentioned. In 1281 Norman iron, of a superior quality, was bought for the Newgate jail. Spain appears to have been the principal source of the supply of imported iron. It is probable that the osemond iron and steel were imported from Sweden and Norway, the osmund furnace having been in use in these countries and in Finland about this time. Iron and steel were generally bought at fairs and markets. The Spaniard attended the Stourbridge fair with his stock of iron, and iron from the Sussex forges was sold at the same place. The prices of iron and steel were usually lower near the sea and at the great towns in the south of England than elsewhere. Among the farmers it was customary for the bailiff to buy the iron that might be needed on the farm, and to employ a smith to make the horseshoes and nails and to iron the implements. Steel appears to have been but little used by the farmers. Rogers says that "no direct information about the seasons, scanty as it is, is so frequent as that found in the notices which the bailiff gives of the great cost of iron." Iron for the tires of wagons and carts was so dear that many wheels were not ironed.

Iron was sold in various forms. The iron made at the works at Tendale was sold in the form of blooms in 1333 and subsequently. Blooms were sold as early as 1318, but the place of their manufacture is not given. Slabs and bars of iron are also mentioned, but the commonest form in which iron was sold was the *piece*, twenty-five pieces constituting a hundred-weight. "The small fagot of iron, each bar of which weighed a little over four pounds, was kept by the bailiff, and served, as occasion required, for the various uses of the farm." The Tendale bloom weighed about one hundred pounds, and was sold at a much lower price than other forms of iron. It was, of course, unrefined iron. Steel was usually sold by the garb, or sheaf, each sheaf containing thirty small pieces, the exact weight of which is not stated. Rogers supposes that the

pieces of iron and steel were of about the same weight, and that the price of steel was about four times the price of iron. Occasional mention is made of steel which was sold by the cake; it was "a little higher in value and much greater in weight than the garb." Steel made in the forges of Styria and other Austrian provinces is still produced in the form of a large cake.

Plow-shoes, which appear to have been iron points to wooden shares, are of frequent occurrence in the accounts quoted by Rogers, and so are lath and board nails, clouts and clout nails, and horseshoes and horseshoe nails. Horseshoes were not purchased from the smiths until about the close of the fourteenth century; down to that time the smiths were supplied by the bailiffs with the iron for their manufacture. "Hinges, staples, and bolts were occasionally manufactured by the village smith, from iron supplied him by the bailiff, but were more frequently bought at the market-town or fair." Iron mattocks and hoes were used in the fourteenth century, as were iron sickles, scythes, and hay and other forks. Domestic utensils of iron were not in general use; pots and similar articles used in the kitchen were usually of brass. A brass jug and pan are mentioned in 1272, a brass jug and basin in 1360, and two brass pots in 1383. Such iron utensils as were in use appear to have been made of wrought iron. Tinware was certainly unknown. Hammers, axes, pickaxes, and other tools were made of iron. Iron hoops were used for buckets and grain measures in the fourteenth century; "the iron-bound bucket that hung in the well" had an existence as early at least as 1331.

Other authorities mention that arrow-heads were manufactured at Sheffield in the thirteenth century, and that knives were manufactured at the same place in the fourteenth century, as they are to-day. Chaucer, who wrote his *Canterbury Tales* near the close of the latter century, in describing the miller of Trompington says that "a Schefeld thwytel bar he in his hose." Birmingham was then, as it is now, a centre of the manufacture of swords, tools, and nails.

Smiles pays a deserved compliment to the English smith, to whom England owes so much of its greatness. In Anglo-Saxon times his person was protected by a double penalty, and

he was treated as an officer of the highest rank. The forging of swords was then his great specialty. William the Conqueror did much to exalt the art of the smith, to whom he was much indebted for his victory at Hastings, his soldiers being better armed than those of the Saxon Harold. At the close of the fourteenth century the smith had fairly entered upon the brilliant career which has since contributed so much to the industrial pre-eminence of England. Mr. Picton, in a recent address, says: "Iron work at this period was of the most elaborate description. The locks and keys, the hinges and bolts, the smith's work in gates and screens, exceed in beauty anything of the kind which has since been produced." In a lecture before the Society of Arts in 1883 Mr. George H. Birch gives a pleasing description of the useful and ornamental treatment of iron by English and Continental smiths from the twelfth to the seventeenth century, dwelling especially upon the elaborate and beautiful hinges, railings, screens, etc., that are still preserved in English, German, French, Spanish, and Italian ecclesiastical and other structures of mediæval and later origin.

England made prominent use of cannon in field warfare at the battle of Cressy and the siege of Calais in the year 1346, when the bowmen of Edward the Third were drawn up "in the form of a harrow," with small bombards between them, "which, with fire, threw little iron balls to frighten the horses." These bombards were made of "iron bars joined together longitudinally, and strengthened by exterior hoops of iron." France, however, according to Scrivenor, appears to have used cannon as early as 1338, in which year it is reported that the government had an account with Henry de Faumichan "for gunpowder and other things necessary for the cannon at the siege of Puii Guillaume." Scrivenor also says that "in the year 1327 we hear of cannon, which are then supposed to have been first used in England, by Edward the Third, in his invasion of Scotland." An English writer, Mr. C. D. Archibald, is said by Lower to have presented strong reasons for the belief that cannon were used by Edward in his expedition against the Scots in 1327. But the archers of the English army continued to be the main reliance of the English kings for many years after Edward's first use of the bom-

bards, and on the Continent gunpowder did not come into general use until the sixteenth century. At the battle of Pavia, in 1525, the match-lock was first used in an effective form, and it was then fired from a rest.

During the fifteenth and sixteenth centuries the manufacture of iron in England was greatly extended. The encouragement which Edward the Third and his immediate successors had given to the immigration of foreign workmen into England had resulted in the settlement in the country of many Flemish and French ironworkers, whose skill was eagerly sought by many landed proprietors who entered with zeal into the manufacture of iron. Sussex became the principal seat of this industry; it possessed both ores and forests, the latter supplying the necessary fuel, and small streams furnished the requisite power to drive the "iron mills." As one marked result of the extension of the iron manufacture in England, the dependence of the country upon foreign sources of supply was greatly lessened; so much so that in 1483 an act was passed prohibiting the importation of gridirons, grates, iron wire, knives, hinges, scissors, and many other manufactured articles of iron or steel which competed with like articles of domestic production. Landrin, however, states that fine tools were still imported from Bilbao, in Spain, as late as 1548.

As early as the beginning of the fifteenth century blast furnaces were introduced into England from the Continent, and this event gave a fresh impetus to the iron industry of Sussex, Kent, Surrey, and other sections. Prior to the introduction of blast furnaces the iron that was made in England was produced in Catalan forges or high bloomaries directly from the ore, and was consequently, when finished, wrought, or bar, iron. Little of it was cast iron. The bloomaries were doubtless modeled after the German *stückofen* during the latter part of the period antecedent to the introduction of the blast furnace. The exact date of the erection of the first blast furnace in England is unknown, but this event must have followed closely upon the introduction of the *flussofen* or *blauofen* on the Continent in the fourteenth century. Lower, in his account of the iron industry of Sussex, mentions an iron casting which was made in Sussex in that century, but this may have been produced by the *stückofen*, or high bloomary.

Mushet supposes that cast iron was made in the Forest of Dean in 1540, and he says that the oldest piece of cast iron he ever saw bore the initials "E. R." and the date "1555." Lower quotes some cast-iron inscriptions in Sussex which are dated 1581, 1582, and 1591. Camden, who lived between 1551 and 1623, says of Sussex: "Full of iron mines it is in sundry places, where, for the making and founding thereof, there be furnaces on every side, and a huge deal of wood is yearly burnt." He also says that the heavy forge-hammers, which were mostly worked by water-power, stored in hammer-ponds, beating upon the iron, "fill the neighborhood round about, day and night, with continual noise." In 1607 John Norden stated in a published document that "there are, or lately were, in Sussex neere 140 hammers and furnaces for iron." In 1615 Simon Sturtevant said that there were then in England, Scotland, Ireland, and Wales "800 furnaces, forges, or iron mills," making iron with charcoal, of which Dud Dudley, a few years later, estimated that about 300 were furnaces, the weekly product of which was about 15 tons each. (We give these figures of Sturtevant and Dudley as they are recorded in Scrivenor, but they would seem to be too high.) At Pontypool, in Monmouthshire, a blast furnace was built in 1565 by Capel Hanbury, to smelt the Roman cinder which was found there, and about the same time several furnaces were built in the Forest of Dean to rework the cinder which was found there in large quantities. The first furnaces built in the Forest were 15 feet high and 6 feet wide at the boshes. The furnaces at work in the Forest in 1677 were blown with bellows 20 feet long, driven by "a great wheel," turned by water.

Lower says that about 1557 "several Sussex families, enriched by the iron manufacture, assumed the rank of gentry." Smiles says that "the iron manufacture of Sussex reached its height toward the close of the reign of Elizabeth, when the trade became so prosperous that, instead of importing iron, England began to export it in considerable quantities in the shape of iron ordnance." This ordnance was cast, and the time referred to was the latter part of the sixteenth century. Bronze cannon had succeeded the bombards about the beginning of that century, and as early as 1543 cast-iron cannon were made in Sussex, at a place called Bucksteed, by Ralph

Hogge, who employed a Frenchman named Peter Baude as his assistant. "Many great guns" were subsequently cast in Sussex—John Johnson and his son Thomas Johnson, the former a servant of Peter Baude, being prominent in their manufacture. John Johnson is said to have "succeeded and exceeded his master in this his art of casting ordnance, making them cleaner and to better perfection." About 1595 the weight of some of the cannon cast in Sussex amounted to three tons each. At a later period, in 1648, Bishop Wilkins, in his *Mathematicall Magick*, says that "a whole cannon weighed commonly 8,000 pounds, a half cannon 5,000, a culverin 4,500, a demi-culverin 3,000. A whole cannon required for every charge 40 pounds of powder and a bullet of 64 pounds."

But a still greater honor is claimed for Peter Baude than that with which his name is above associated. Stow, in his *Chronicle*, quoted by Froude and Smiles, says that two foreign workmen, whom Henry the Eighth tempted into his service, first invented shells. "One Peter Baude, a Frenchman-born, and another alien called Peter Van Cullen, a gunsmith, both the king's feed men, conferring together, devised and caused to be made certain mortar pieces, being at the mouth from 11 inches unto 19 inches wide, for the use whereof they caused to be made certain hollow shot of cast iron, to be stuffed with fire-work or wild-fire, whereof the bigger sort for the same had screws of iron to receive a match to carry fire kindled, that the fire-work might be set on fire for to break in pieces the same hollow shot, whereof the smallest piece hitting any man would kill or spoil him." Lower gives the name of the alien above referred to as "Peter Van Collet, a Flemish gunsmith."

There is deposited in the library of the Historical Society of Pennsylvania, at Philadelphia, a stone cannon-ball, one of twenty-three which are said to have been fired at the boat in which Queen Mary and Douglass made their escape from Loch Leven in 1568. It is about 8 inches in diameter, is round, but not smooth, and weighs probably 15 pounds.

The exportation of cast-iron cannon became so extensive that complaint was made that Spain armed her ships with them to fight the ships of England, and the trade was for a time prohibited. But their manufacture continued on a large

scale, and many were surreptitiously exported. Hume says that "shipbuilding and the founding of iron cannon were the sole manufactures in which the English excelled in James the First's reign," from 1603 to 1625. In 1629 the crown ordered 600 cannon to be cast for the States of Holland. England, however, continued to import from the Continent, particularly from Sweden, Germany, and Spain, some of the finer qualities of iron and considerable steel.

Before 1568 all iron wire that was made in England was "drawn by main strength alone," according to Camden. The Germans, says this author, then introduced into the Forest of Dean and elsewhere the art of drawing it by a mill. Previous to the year mentioned the greater part of the iron wire and ready-made wool-cards used in England was imported. Scrivenor quotes Williams's *History of Monmouthshire* as authority for the statement that the iron and wire works near Abbey Tintern were erected by Germans. There can be no doubt that the iron industry of England in the fourteenth, fifteenth, and sixteenth centuries was greatly indebted to the inventive genius and mechanical skill of emigrants from Continental countries.

Near the close of the sixteenth century there was introduced into England an invention for slitting flattened bars of iron into strips called nail-rods. This invention was the slitting mill. Scrivenor, upon the authority of *Gough's Camden*, states that Godfrey Bochs, of Liége, Belgium, set up at Dartford, in 1590, "the first iron mill for slitting bars." Dartford is a market town in Kent. Another story associates the name of "the founder of the Foley family, who was a fiddler living near Stourbridge," with the honor of introducing the first slitting mill into England, a knowledge of which he surreptitiously gained by visiting Swedish iron works and fiddling for the workmen. Percy states that Richard Foley, the founder of the Foley family at Stourbridge, who was first a seller of nails and afterwards a forgemaster, died in 1657 at the age of 80 years. In 1606 and 1618 patents were granted in England to Sir Davis Bulmer and Clement Dawbeny, respectively, for cutting iron into nail-rods by water-power. The slitting mill, by whomsoever invented and perfected, greatly benefited the nail trade of England. Birmingham became the centre of

this industry, and it was here, probably, that women and girls were first regularly employed in England in the manufacture of nails. Hutton, quoted by Young in his *Labor in Europe and America*, says that in 1741 they were thus employed in the numerous blacksmith shops of Birmingham, "wielding the hammer with all the grace of their sex." They were called "nailers." Machinery was not applied to the manufacture of nails until near the close of the eighteenth century. Nail-cutting machinery is an American invention.

The art of tinning iron was first practiced in Bohemia, and about 1620 it was introduced into Saxony. These countries for a time supplied all Europe with tin plates. In 1681 Andrew Yarranton asserted that tin plates were then made in England through his means, he having learned the art of making them in Saxony in 1665. The exact date of the introduction of the manufacture of tin plates into England by Yarranton is said to have been 1670. The first attempt to establish the new industry in England was made at Pontypool, in Monmouthshire. Scrivenor states that in 1740 the art "was brought to considerable perfection in England."

But, notwithstanding the progress which had been made in the development of the English iron trade, especially in the reigns of Henry the Eighth, Elizabeth, and James the First, an influence was at work which was destined to weigh heavily for a hundred and fifty years upon all further development. This was the growing scarcity of wood for the use of the forges and furnaces—mineral fuel, or pit-coal, not yet having come into use as a substitute for wood. The forests of England in the ironmaking districts had been largely consumed by "the voracious iron mills," and there were loud complaints that the whole community would be unable to obtain fuel for domestic purposes if this denudation were persisted in. In response to these complaints an act was passed in 1558, the first year of the reign of Elizabeth, which prohibited the cutting of timber in certain parts of the country for conversion into coal or fuel "for the making of iron," special exception being made of the Weald of Kent, the county of Sussex, and certain parishes "high in the Weald of the county of Surrey." In 1581 a further act to prevent the destruction of timber was passed, which set forth the increasing

scarcity of timber for fuel in consequence of "the late erection of sundry iron mills in divers places not far distant from the city of London and the suburbs of the same, or from the downs and sea-coast of Sussex," and provided that "no new iron works should be erected within twenty-two miles of London, nor within fourteen miles of the river Thames," nor in certain parts of Sussex near the sea; nor should any wood within the limits described, with certain exceptions, be converted "to coal or other fewel, for the making of iron-metal in any iron-mill, furnace, or hammer." A more sweeping act was passed in 1584, which prohibited the erection of any new iron works in Surrey, Kent, and Sussex, and ordered that no timber one foot square at the stub should be used as fuel "at any iron work." It is said that these restrictions were not very rigidly enforced, but they served to narrow the limits within which the manufacture of iron could be conducted, although they did not abridge the manufacture itself. Lower says that in the early part of the reign of Charles the First, who was beheaded in 1649, "the number of mills and furnaces had increased yearly, in spite of the statutes limiting their extension, and the waste of timber was again brought before the notice of government." This increase, however, was probably in districts of the country that had not previously been largely devoted to the manufacture of iron. Dudley, in his *Metallum Martis*, says that about 1620 there were nearly 20,000 smiths of all sorts within ten miles of Dudley Castle, in Staffordshire, and that there were also "many iron works at that time within that circle decayed for want of wood (yet formerly a mighty woodland country)."

About the middle of the seventeenth century the British iron industry experienced a serious check through the civil commotion which then prevailed. Many of the forges and furnaces in Sussex and in the south of Wales were then destroyed, and not again rebuilt. Soon after the Restoration all the royal iron works in the Forest of Dean were destroyed, owing to the scarcity of timber. There was then much apprehension felt lest the Forest of Dean should fail to supply timber for the royal navy. Owing to the scarcity of timber many of the iron works in Kent, Sussex, Surrey, and in the north of England were "laid down" in 1676, and England's

supply of iron was largely derived from "Sweadland, Flanders, and Spain."

Notwithstanding these severe checks the iron industry of England bravely refused to be utterly destroyed, and as late as 1720 it was still second in importance to the manufacture of woolen goods. In 1724 it was the chief industry of Sussex. In 1740, however, only 59 furnaces were left in all England and Wales, and their total production was but 17,350 tons of pig iron, or about 294 tons for each furnace. All these furnaces may not have been in blast, as it has been stated that, ten years later, in 1750, each of the charcoal furnaces of Monmouthshire produced 24 tons of iron in a week. Ten of the furnaces existing in 1740 were in Sussex, but in 1788 only two of these were left, and in 1796 only one is mentioned. In 1740 there were 10 charcoal furnaces in the Forest of Dean. Pig iron is still made in this district, but with coke as fuel. The iron industry of Kent and Sussex and Surrey is now extinct. The last furnace in the Weald of Sussex, at Ashburnham, was blown out in 1829.

During the seventeenth and eighteenth centuries England imported iron largely from Sweden, and in the latter century both Russia and the American colonies contributed to her supply. The scarcity of timber for fuel for blast furnaces in England continuing, a proposition was made in the British Parliament in 1737 to bring all pig iron from the British colonies in America; and in 1750, to facilitate the importation of pig iron from these colonies, the duty which had previously been imposed for the protection of British pig-iron manufacturers was repealed. At this time the business of manufacturing pig iron in some parts of Great Britain was conducted upon such primitive principles that both charcoal and iron ore were carried to the furnaces of Monmouthshire on the backs of horses.

Soon after the passage of the act of 1750 mineral coal in the form of coke came into general use in the manufacture of pig iron in England, and the iron trade of that country and Wales at once revived, while that of Scotland may be said to have been created by the new fuel. As early as the beginning of the preceding century the celebrated and unfortunate Dud Dudley had experimented in England in the manufacture of

iron with raw coal, but the first truly successful use of mineral coal in the blast furnace was by Abraham Darby, of Shropshire, at his furnace at Coalbrookdale, in 1735. This coal was coked. In 1740 a coke furnace was built at Pontypool, in Monmouthshire. In 1796 charcoal furnaces had been almost entirely abandoned in Great Britain. The manufacture of pig iron with mineral coal was greatly facilitated by the invention of a cylindrical cast-iron bellows by John Smeaton in 1760, to take the place of wooden or leather bellows, and by the improvements made in the steam engine by James Watt about 1769—both these valuable accessions to blast-furnace machinery being used for the first time, through the influence of Dr. Roebuck, at the Carron iron works in Scotland. The effect of their introduction was to greatly increase the blast and consequently to increase the production of iron. The blast, however, continued to be cold at all furnaces, both coke and charcoal, and so remained until 1828, when James Beaumont Neilson, of Scotland, invented the hot-blast.

These and other changes in the manufacture of pig iron were accompanied by equally important improvements in the manufacture of finished iron. In 1783 Henry Cort, of Gosport, England, obtained a patent for rolling iron into bars with grooved iron rolls, and in the following year he obtained a patent for converting pig iron into malleable iron by means of a puddling furnace. These patents did not relate to absolutely new inventions in the manufacture of iron, but to important improvements on existing methods, which had not, however, been generally employed. Mineral coal was from this time forward used in the puddling furnace as well as in the blast furnace; it had long been used in refineries. To the improvements introduced by Cort the iron trade of Great Britain is greatly indebted. The refining of pig iron in forges and its subsequent conversion into bars and plates under a tilt-hammer formed virtually the only method of producing finished iron down to Cort's day, both in Great Britain and on the Continent, and it was wholly inadequate to the production of large quantities of iron of this character. With mineral fuel, powerful blowing engines, the puddling furnace, and grooved rolls Great Britain rapidly passed to the front of all iron-making nations. But the foundation of this progress was

the possession of mineral fuel, or pit-coal, of superior quality and in large and apparently inexhaustible quantities. On the Continent at this time the pit-coal that had been developed was supposed to be unsuited to the manufacture of iron.

Steel was largely made in England as early as 1609, and probably in cementation furnaces. In that year John Hawes held the site of the abbey of Robertsbridge, in Sussex, upon which were eight steel "furnaces." The invention of crucible cast steel originated with Benjamin Huntsman, an English clockmaker, about the middle of the eighteenth century, and not only Sheffield, the principal seat of its manufacture and of the manufacture of fine cutlery, but all England as well, has greatly profited by his discovery. At the beginning of the seventeenth century Sheffield contained only 2,207 persons; at the census of 1881 it had 284,508. A curious document is extant which sets forth that, "by a survaie of the towne of Sheffild, made the second daie of Januarie, 1615, by twenty-four of the most sufficient inhabitants there, it appeareth that there are in the towne of Sheffild 2,207 people; of which there are 725 which are not able to live without the charity of their neighbours; these are all begging poore. One hundred householders which relieve others. These (though the best sorte) are but poor artificers; among them there is not one that can keep a teame on his own land, and not above tenn that have ground of their own that can keep a cow. One hundred and sixty householders not able to relieve others. These are such (although they beg not) as are not able to abide the storme of one fortnight's sickness, but would be thereby driven to beggary. One thousand two hundred and twenty-two children and servants of the said householders, the greatest part of which are such as live of small wages, and are constrained to work sore to provide them necessaries." As late as 1736 the population of Sheffield was only 10,121. Benjamin Huntsman was born in Lincolnshire in 1704, of German parents, and died on June 20, 1776, at Attercliffe, near Sheffield. The manufacture of cemented steel also became a leading industry of Sheffield in the eighteenth century.

We now turn from the iron industry of England to that of Wales, Ireland, and Scotland.

It has already been stated that iron was made in South

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Wales during the Roman occupation of Britain, and, as the Welsh were a somewhat exclusive and practically an independent people down to a comparatively recent period, it may be assumed that they have never since ceased to make iron. In the sixteenth century, owing to the great scarcity of timber in England, some of the ironmasters of Sussex emigrated to Glamorganshire, in South Wales, where they founded the iron works of Aberdare and other iron works. Remains of the works in the Aberdare valley still exist. The active development of the extensive iron industry of Merthyr Tydvil appears, however, to date from about 1755. In 1770 the first coke furnace in South Wales was built at Cyfartha. In 1788 there were six coke furnaces in South Wales. Cort's inventions were promptly appropriated by Welsh ironmasters.

According to Scrivenor, iron-ore mines were opened in Ireland by the English who settled in the country during the reign of Elizabeth, and iron itself was extensively manufactured in Ireland by the English during the reign of James the First and afterwards. The most extensive works were in the provinces of Munster, Connaught, and Ulster, and in the counties of Queens, Kings, and Thomond. In some instances iron ore was taken from England to the sea-coast of Ulster and Munster, in Ireland, the latter country then abounding in forests, but generally Ireland supplied both the ore and fuel. Most of the iron produced was in bars from forges, but ordnance, pots, and other articles were also cast in foundries or furnaces. The Rebellion of 1641 put an end to many of the English iron works in Ireland, some valuable works in the county of Mayo escaping. In 1660 Sir William Petty estabblished extensive iron works in the county of Kerry, which continued in operation until the middle of the eighteenth century, when they were stopped in consequence of the scarcity of timber. In 1672 this gentleman stated that one thousand tons of iron were then made in Ireland. Near the close of the seventeenth century an act of the British Parliament remitted the duties on bar iron and on iron slit and hammered into bars imported from Ireland, the manufacturing industries of Ireland being then greatly depressed. The iron industry of Ireland survived until the reign of George the Second, in the early part of the eighteenth century, when it

came to an end in consequence of the scarcity of timber, the competition of English iron, and the unsettled condition of the country. An effort was made to revive it at the close of the century, but it met with slight success. In 1840 there were no iron works in Ireland "going on." In 1857 there was but one furnace yet standing in Ireland. There are now no iron works in the country. Irish ores were imported into the United States in 1879 and 1880, and in more recent years.

It has already been stated that iron was very scarce in Scotland in the closing centuries of the middle ages, Scotland obtaining all her supplies of iron at that time from outside her borders. The Scotch, however, were noted during the period mentioned for the excellence of their swords and armor, the former vying in temper with those of Toledo and Milan. In Sir Walter Scott's story of *The Fair Maid of Perth*, the events of which are supposed to have occurred during the last years of the fourteenth century, the hero, Henry Gow, is an armorer—a forger of swords and bucklers and coats-of-mail. In 1547 an English chronicler wrote that "the Scots came with swords all broad and thin, of exceeding good temper, and universally so made to slice that I never saw none so good, so I think it hard to devise a better." Scotland had no noteworthy iron-producing industry of her own until the middle of the eighteenth century. It is conjectured, however, that her ancient inhabitants may have made iron in very small quantities, as pieces of iron slag have been discovered in the ruins of Celtic fortified towns in the Cheviot hills, on the boundary between England and Scotland. Mr. Richard Meade informs us that the earliest information bearing on iron smelting in Scotland dates from 1750, in which year its first furnace was erected at Bunawe, in Argyleshire, by a Mr. Ford. In this furnace the blast was driven by water-power obtained from the river Awe, the ore used being brought from Ulverstone, in Lancashire, while charcoal was exclusively used as fuel. The Bunawe furnace, now known as the Lorne, is still in existence, although not in operation. Some time previous to 1788 a similar furnace was erected at Goatfield, also in Argyleshire. A short time prior to 1760 the first blast furnace at the celebrated Carron iron works, in Stirlingshire, was put in operation, and for some time charcoal was used. Min-

eral coal was soon substituted for charcoal at this furnace, and from that time forward the iron industry of Scotland was rapidly developed. In 1788 there were six coke furnaces in Scotland and the two charcoal furnaces of Bunawe and Goatfield. The manufacture of carronades was long a specialty of the Carron iron works, from which they took their name.

The following statistics will show how rapidly the manufacture of pig iron in Great Britain has grown in the last hundred years. In 1788 there were 77 furnaces in England and Wales and 8 furnaces in Scotland, and their total production was 68,300 tons. Of the whole number of furnaces, 26 used charcoal and 59 used coke. The imports of iron by Great Britain in this year amounted to about 15,000 tons. In 1796 there were 104 furnaces in England and Wales, producing 108,793 tons of iron, and in Scotland there were 17 furnaces, producing 16,086 tons. In 1806 there were 173 furnaces in Great Britain, producing 258,000 tons. In 1820 there were 284 furnaces, producing 400,000 tons. In 1827 the production was 690,500 tons. In 1840 it was 1,396,400 tons. In 1854 it rose to 3,069,838 tons. This quantity was then estimated to be fully one-half of the world's production of pig iron. The same proportion was steadily maintained by Great Britain for many years, but it is now lost. In 1857 Great Britain's production of pig iron was 3,659,447 tons, smelted from 9,573,281 tons of ore in 628 blast furnaces, (not all in operation, however,) of which 333 were in England, 170 in Wales, 124 in Scotland, and 1 in Ireland. In 1872 the production was 6,741,929 tons; in 1880 it was 7,749,233 tons; in 1882 it was 8,586,680 tons. For several years there have been only 4 charcoal furnaces in Great Britain, and these have produced but little iron, less than 3,000 tons annually. The whole number of blast furnaces in Great Britain in 1882 was 929, only 570 of which were in blast.

The eighteenth century marked a new era in all those branches of manufacturing industry in which the British people have become prominent. It was the era of machinery, which then began to receive general attention as a substitute for hand labor. This era gave to the people of Great Britain the manufacture of Indian cotton goods, and it largely increased their woolen manufacture and wonderfully develop-

ed their iron manufacture. It was in the eighteenth century that Great Britain, in consequence of her quick appreciation of the value of labor-saving machinery, became the first manufacturing nation in the world; in the preceding century four-fifths of the British working people were still farmers or farm laborers. During the latter part of the eighteenth century and the whole of the nineteenth century down to the present time no other country has occupied so conspicuous a position in the manufacture of iron and steel as Great Britain. Spain and Germany had in turn been more prominent in the production of these essentials of civilization, but Great Britain spurned all rivalry when she began to make pig iron with the aid of mineral fuel and her powerful blowing engines. She had an abundance of iron ores and mineral coal, and her people had applied to the utilization of these products their invincible energy and their newly-developed inventive genius. France, Germany, and other Continental countries might have substituted mineral coal for charcoal, invented the puddling furnace, or perfected the rolling mill and the steam engine, but none of them did. To England and Scotland is the world indebted for the inventions that gave a fresh impetus to the manufacture of iron in the eighteenth century; Huntsman, Darby, Smeaton, and Cort were Englishmen, and Watt was a Scotchman; and it is also indebted to the same countries for most of the inventions of the present century which have further developed the manufacture of iron and increased the demand for it, and which have almost created the manufacture of steel. Stephenson, the Englishman, improved the locomotive in 1815, and in 1825 the first passenger railroad in the world was opened in England, Stephenson's locomotive hauling the trains. Neilson, the Scotchman, invented the hot-blast in 1828; Crane, the Englishman, applied it to the manufacture of pig iron with anthracite coal in 1837; Nasmyth, the Scotchman, invented the steam hammer in 1838 and the pile-driver in 1843; and Bessemer, the Englishman, invented in 1855 the process which bears his name and is the flower of all metallurgical achievements—a share in the honor of this invention, however, being fairly due to the co-operating genius of Robert F. Mushet, also an Englishman, but of Scotch parentage. The Siemens regenerative gas furnace, which has

been so extensively used in the manufacture of iron and steel, is also an English invention, although the inventors, Sir William and Frederick Siemens, while citizens of England, were natives of Hanover, in Germany.

It is proper to add that Sir Henry Bessemer, although born in England, is the son of a French refugee who settled in England during the Revolution of 1789, and that Benjamin Huntsman, the inventor of the process for manufacturing cast steel in crucibles, was the son of German parents, although himself born in England. It was, however, enterprising and sturdy England that nursed the genius of the great inventors we have mentioned who were of Continental birth or extraction.

That Great Britain did not at first seek to extend the influence of her new light and life to other countries, but by various acts of Parliament sought to prevent the introduction of her inventions and the emigration of her skilled artisans into those countries, is not here a subject of comment; nor is the strict adherence of Great Britain to a policy of protection to home industries by customs duties during many centuries and down to almost the middle of the present century a subject of present comment. Both measures undoubtedly fostered the growth of British manufacturing industries, and in the end the world was benefited by British inventions, which found their way across the English channel and the Atlantic ocean, and by the example of British energy and British enterprise in the utilization of native manufacturing resources.

CHAPTER IV.

EARLY PROCESSES IN THE MANUFACTURE OF IRON.

Except incidentally the various processes for the manufacture of iron which were in use in the early ages of the world's history, as well as in more recent times, have not been referred to in the preceding pages. Further notice of some of the processes that were successively in use before the beginning of the present century seems, however, to be desirable, if for no other reason than to show how rude and unproductive were those processes in comparison with the improved methods that are now in use, and with which the reader is supposed to be more or less familiar.

The methods of manufacturing iron that were in use in Asia and Africa in the earliest ages were few in number and of extreme simplicity. All of them produced wrought iron with the aid of wood or charcoal as fuel, although steel was also produced by some of them. One of these early processes, which still exists in Burmah, required no artificial blast. A perpendicular circular excavation, ten or twelve feet deep and open at the top, was made in the side of a bank or hillock, in which ore and fuel were placed in alternate layers, and to which the necessary draft for combustion was applied through one or more openings near the bottom. The product was a lump, or bloom, of iron. Another process applied an artificial blast to a small excavation in the ground, or to a low furnace built of clay or stone and standing alone, the product being also a lump of iron. This artificial blast was supplied by bellows, which were usually made of goat skins, having a nozzle or tuyere of bamboo or burnt clay, and were worked by the feet or hands. Goat-skin bellows are in use in India and in the interior of Africa to-day in connection with small furnaces. It is interesting to note the fact that the bellows and its tuyere, or nozzle, both of which in some form are in universal use to-day wherever iron is made, are undoubtedly of prehistoric origin and that they are still used in their original simplicity in the manufacture of iron. In some parts of

India, and in China, Japan, Borneo, and Madagascar, blowing cylinders of wood or bamboo, having valves and pistons, and worked like a pump by manual labor, are now used, and were probably used in remote ages. The bloom of iron, whether produced by natural or artificial blast, was reheated, and freed from impurities and adhering charcoal by repeated hammering, in the course of which refining operation it was divided into suitable parts for practical use. The fire of the smith who gave to the iron its final shape was supplied with a goat-skin or bamboo blast. The blacksmiths of India use a blast of this character at the present time. The ore which was smelted by these primitive processes was broken into small pieces and otherwise carefully prepared. In some parts of India and in several other Asiatic countries the ore was magnetic and well adapted to the manufacture of steel.

In the years 1881 to 1883 a French scientific commission, inquiring into the mineral resources of Indo-China, visited the important deposit of iron ore at Ph'nom Deck, in the province of Compong-Thom, in Cambodia.* The manner in which this ore is converted into iron is very suggestive of the ancient methods which have been briefly described above.

The native Khouys manufacture a small quantity of extremely pure iron, for which there is a great demand; it is exported to considerable distances, and serves as money over an immense area. A mixture of the ores is used, the chief being a brown hematite, containing under 40 per cent. of metallic iron, with over 2 per cent. of manganese, and associated with the surrounding tuff. The metallurgy is divided into two parts: first, the fabrication of an iron-sponge; and, second, the elaboration of the sponge and its transformation into small hammered bars. The sponge is made in a rectangular furnace, 8 feet by 3 feet, and 16 inches deep, which is constructed on a mass of earth nearly 3 feet above the ground. The walls and base of the furnace consist of refractory earth, mixed with very fine white sand. The charge is about 4 cwts. of mineral, with about 15 bushels of charcoal, in thin alternate layers.

The operation continues slowly for eight hours, the blast being distributed from a great number of bamboo tuyeres, the bellows, of curious construction, being made of buffalo and deer-skins; afterwards for two to four hours the blast is much stronger. During the operation the slag is frequently removed. The resulting sponge is sold to the native forges to be made into bars, which is accomplished by a laborious and primitive process. The bars are far from being homogeneous, some parts being of a steely character alternating with portions of soft iron. The bars weigh about 1 pound, and sell through Cambodia and Siam at prices attaining the rate of £60 per ton.

The celebrated Indian steel, or wootz, which is chiefly used for the manufacture of sword blades, is obtained at the present time by remelting pieces of native iron in small crucibles, which are only a few inches high, containing finely-chopped wood, the crucibles being placed in a furnace heated with a blast supplied by bellows made usually of goat skins or bamboo cylinders. To reduce excessive carbonization, and also to soften the steel so that it may be drawn into bars, the lumps or cakes of steel thus obtained are heated in a charcoal fire blown by a bellows, the current of air being made to play upon the cakes while they are turned over before it. More than two thousand years ago the process was the same that it is now. It is fully described by Aristotle, who lived in the fourth century before Christ. China is said by Day to have made steel long before the Christian era by the method revived in modern times of immersing wrought iron in a bath of cast iron.

The manner in which the air was expelled from the goat-skin bellows of antiquity doubtless varied in different countries, but the pressure of the feet of one workman on two such bellows, attached to a common nozzle or tuyere, was probably the method in most general use. This method is still used in Africa. Wilkinson, in his *Manners and Customs of the Ancient Egyptians*, quoted by Day, mentions his discovery on the walls of a tomb built in the reign of Thothmes the Third, at Thebes, about fifteen centuries before the Christian era, of the picture of an Egyptian furnace and bellows, with two workmen engaged in expelling with their feet the air from as many pairs of bellows, "consisting of flexible bags formed of the skins of animals, and each provided with a cord which the operator holds in his hands. From each of these flexible bags a tube proceeds into the heap of fuel and ore, and the blast is produced by the operator transferring the weight of his body alternately from one foot to the other. The bags are inflated by pulling up the upper part by the cord, this upper part having a hole or valve therein for allowing the air to enter, and which is closed by the heel of the operator on his again transferring his weight to it."

The primitive processes for manufacturing iron, or modifications of them, were adopted in Europe when that conti-

nent commenced to make iron. The manufacture of iron in Belgium and in England without the aid of an artificial blast, about the time of the Christian era, has already been referred to. It is not known whether other European countries ever made iron in the same way. At Lustin, in Belgium, between Namur and Dinant, two ancient furnaces or bloomaries were discovered in 1870, on the top of a hill, with iron yet remaining in them. They consisted of simple oval excavations with rounded bottoms in a bed of clay, each 12 feet long and 9 feet wide, with a depth in the middle of 3 feet, the top being level with the surface of the surrounding soil. A channel excavated in the clay, but covered over with stones, conducted the wind into the lower portion of each furnace. The opening of this channel was turned in the direction of the prevailing wind, so that iron could only have been made on windy days. These bloomaries contained lumps of crude wrought iron.

The English antiquarian, Thomas Wright, in *The Celt, the Roman, and the Saxon,* quotes from Mr. Bruce's account of the Roman Wall a statement concerning the discovery not many years ago of the character of the blast used in "the furnaces of the extensive Roman iron works" in the neighborhood of Epiacum, (Lanchester,) in England. Mr. Bruce says: "Two tunnels had been formed in the side of a hill; they were wide at one extremity, but tapered off to a narrow bore at the other, where they met in a point. The mouths of the channels opened toward the west, from which quarter a prevalent wind blows in this valley, and sometimes with great violence. The blast received by them would, when the wind was high, be poured with considerable force and effect upon the smelting furnaces at the extremity of the tunnels." In a foot-note Mr. Wright adds the following, which is curiously suggestive of the hot-blast: "We are told by the early Spanish writers that the Peruvians built their furnaces for smelting silver on eminences where the air was freest; they were perforated on all sides with holes, through which the air was driven when the wind blew, which was the only time when the work could be carried on, and under each hole was made a projection of the stonework, on which was laid burning coals to heat the air before it entered the furnace."

As no evidence exists that iron was ever made by the

Romans in the south of Europe without the aid of an artificial blast, it may be fairly assumed that the Belgian furnaces above described and the methods of manufacture in England which are described by Mr. Bruce and others are of native origin. The Romans may for a time have continued the native practice, especially as the manufacture of iron in both Belgium and Britain would be mainly confined to the native inhabitants, but long before their withdrawal from these countries in the fifth century the superior practice of Southern Europe would be generally introduced.

In the south of Europe the bellows was certainly used to produce a blast long before the Roman invasion of Britain. Homer, quoted by Fairbairn, "represents Hephæstus as throwing the materials from which the shield of Achilles was to be forged into a furnace urged by twenty pairs of bellows." The bellows first used by the Greeks were probably made of goat skins, but subsequently, as early probably as the time of Homer, and certainly as early as the third century before Christ, larger and more powerful bellows were made of the hides of cattle, and larger furnaces or bloomaries were erected. These larger bellows were substantially the same as the common blacksmith's bellows of our day, and they would be used by the Greeks and Romans in smelting the ore as well as in refining and shaping the iron. Of their furnaces and forges we know but little. Virgil, who lived in the first century before Christ, gives us in the Fourth Georgic a view of a refinery forge as it doubtless existed among the Romans in his day, although located by the poet in a fabulous age.

> As when the Cyclops, at th' almighty nod,
> New thunder hasten for their angry god,
> Subdued in fire the stubborn metal lies:
> One brawny smith the puffing bellows plies,
> And draws and blows reciprocating air:
> Others to quench the hissing mass prepare:
> With lifted arms they order every blow,
> And chime their sounding hammers in a row:
> With labored anvils Etna groans below.
> Strongly they strike; huge flakes of flames expire:
> With tongs they turn the steel and vex it in the fire.

Diodorus of Sicily, quoted by Scrivenor, mentions the iron ores of Elba, "which the natives dig and cut out of the ground

to melt, in order for the making of iron, much of which metal is in this sort of stone. The workmen employed first cut the stone in pieces, and then melt them in furnaces built and prepared for the purpose. In these furnaces the stones, by the violent heat of the fire, are melted into several pieces in form like great sponges, which the merchants buy by truck and exchange of other wares, and export them to Dicœarchea and other mart towns. Some of these merchants that buy of these wares cause them to be wrought by the coppersmiths, who beat and fashion them into all sorts of tools, instruments, and other shapes and fancies; some they neatly beat into the shape of birds, others into spades, hooks, and other sorts of utensils, all which are transported and carried about into several parts of the world by the merchants." This account was written in the first century before Christ.

Pliny describes the various kinds of iron and steel which were in use in his day, the first century after Christ, but gives us little insight into the methods by which they were produced. In the following obscure description he seems to have intended to show that both iron and steel were made in the same furnace, and that the quality of both these products varied greatly. He says: "There is a great difference, too, in the smelting; some kinds producing knurrs of metal, which are especially adapted for hardening into steel, or else, prepared in another manner, for making thick anvils or heads of hammers. But the main difference results from the quality of the water into which the red-hot metal is plunged from time to time. The water, which is in some places better for this purpose than in others, has quite ennobled some localities for the excellence of their iron, Bilbilis, for example, and Turiasso in Spain, and Comum in Italy, and this although there are no iron mines in these spots. It is a remarkable fact that when the ore is fused the metal becomes liquefied like water, and afterwards acquires a spongy, brittle texture. It is the practice to quench the smaller articles made of iron with oil, lest by being hardened in water they should be rendered brittle. Iron which has been acted upon by fire is spoiled unless it is forged with the hammer. It is not in a fit state for being hammered when it is red hot, nor, indeed, until it has begun to assume a white heat."

In Spain, as we have seen, iron and steel were made many centuries before Pliny's time, the Catalan forge, or a modification of it, being used, and the product being either wrought iron or steel. The Catalan forge differed in no essential particular from the ordinary fire of a blacksmith, except that it had a sunken hearth, or crucible. The Corsican forge, which also existed before the Christian era, was a modification of the Catalan forge. The blast for these forges is presumed to have been primarily furnished by bellows made of goat skins or the skins of other small animals, but larger Grecian and Roman bellows were afterwards substituted. Bauerman, in his *Treatise on the Metallurgy of Iron*, cites Franquoy as authority for the statement that bellows with valves, "single acting and made of leather," were introduced by the Romans into Gaul in the fourth century of the Christian era.

Percy copies the following description of an old Catalan forge in Spain: "In 1823, at Bielsa, in Aragon, in the Spanish Pyrenees, some charcoal burners discovered in a forest of silver firs a small circular iron furnace only 2 feet and 1.59 inches high. The lower part or hearth was cylindrical up to the height of about 11.81 inches and then terminated in an inverted truncated cone; its diameter was 14.25 inches at the lower and 1.69 inches at the upper part; it had two tuyere beds at 11.81 inches from the bottom. Near the furnace were found two crude lumps of iron in the state in which they appeared to have been taken out, and which weighed from 30.9 pounds to 35.3 pounds. According to tradition the blast in these furnaces was produced with bellows of skin worked by hand. Accumulations of ancient slags are met with at high elevations in the Pyrenees, far from any water-course, and which doubtless were urged by a blast produced by manual labor." Scrivenor speaks of portable forges in ancient France, and we have already referred to the movable forges of the Forest of Dean. These references suggest the portable blacksmith's forge of the present day.

An analysis of the piece of iron found under the Egyptian obelisk which was removed in 1880 to New York shows that it must have been made by the direct process, and probably in a Catalan forge. The analysis, which was made for A. L. Holley by Dr. August Wendel, of Troy, is here preserved.

Iron	98.738	Copper	0.102
Carbon	0.521	Calcium	0.218
Sulphur	0.009	Magnesium	0.028
Silicon	0.017	Aluminium	0.070
Phosphorus	0.048	Slag	0.150
Manganese	0.116		
Nickel, Cobalt	0.079	Total	100.096

Mr. Holley says that a clean fracture of the iron was similar to that of puddled steel, and mentions the further fact that the small amount of slag, as well as the fine fracture, indicates frequent reworking.

Much light is thrown upon the methods of manufacturing iron which prevailed in the south of Europe at the beginning of the Christian era by the discovery in 1870 of two ancient bloomaries or melting hearths in the vicinity of Hüttenberg, in Carinthia, on the Hüttenberg railway. The place where these hearths were found is embraced within the limits of the ancient province of Noricum. Maw and Dredge thus describe these hearths :

In the year 1870 a most interesting discovery was made during the construction of the Hüttenberg railway. In a cutting a set of iron melting-hearths of Roman and Celtic times was found 6 feet below the present surface of the ground. These hearths consist of two holes or ditches, the upper one being supposed to have served as a calcining kiln, whilst the lower one represents the smelting furnace proper. These hearths were found near the mines of spathic ore in the neighborhood of Hüttenberg.

The calcining hearth is fitted with a layer of charcoal 1½ inches thick, upon which a 10-inch layer of clay forms the inside lining of the hearth. This lining was found burnt by the action of the calcining fire to a depth of 4 inches. The depth of the hearth is 2 feet, and its diameter 5 feet. The second or smelting hearth is placed at a distance of 16 feet from the former, and is 3 feet deep and 4 feet wide. The lining consists of a layer of 6-inch clay, upon which a fire-brick mass, consisting of clay and quartz, is uniformly spread to a thickness of 12 inches. This lining is burnt and glazed to a depth of 3 inches at the inner side, thus recording the higher temperature in this hearth during the smelting operation.

Both hearths are filled with *débris* of burnt clay and slag crumbled down from the walls of the hearths, which seem to have been raised one foot above the surface of the ground. The space between the two hearths is paved with stones. The slag contains many unburnt pieces of charcoal. The analysis of the slag has proved that the yield of the spathic ore in use, containing from 50 to 60 per cent. of iron, was only 15 to 20 per cent. The blast seems to have been furnished by bellows from the top of the furnaces. A Roman cornice has been found near the smelting hearth.

These discoveries point out a very primitive process as compared with our present means of iron smelting; but centuries vanished before any real improvements were introduced. Nevertheless we find that the preparatory calcination of the ore previous to its being introduced in the smelting furnace is a very ancient mode of economizing labor and fuel.

With the exception of the Indian process for making steel, the various processes which have been referred to were all *direct* processes, the iron or steel being obtained directly from the ore. The furnaces, whether high or low, large or small, were all *bloomaries*, because the product derived from the heated ore was obtained in the form of a lump or bloom of malleable iron or steel. If cast iron was sometimes obtained by the Mediterranean nations, or by Asiatic and African iron-workers, very little evidence exists that it was run into moulds for the production of useful or ornamental castings. The weakness of the blast furnished by goat skins, bamboo, or the early blacksmith's bellows renders it highly improbable that much cast iron was ever obtained by any of the ancient processes. Aristotle, who lived in the fourth century before Christ, has left an account of the manner in which the Greeks of his day converted wrought iron into steel, which furnishes some evidence that they were also familiar with cast iron. He is quoted by Day as follows: "Wrought iron itself may be cast so as to be made liquid and to harden again; and thus it is they are wont to make steel; for the scoria of iron subsides and is purged off by the bottom; and when it is often defecated and made clean this is steel. But this they do not often because of the great waste and because it loses much weight in refining; but iron is so much the more excellent the less recrement it has." The quotation from Pliny on a preceding page contains the most direct evidence we have of the making of cast iron by the Romans. But, if the Mediterranean nations, and particularly the Greeks and Romans, knew how to make and utilize cast iron, this knowledge virtually became one of the lost arts, for there is no authentic mention of cast iron having been made in the northern and western parts of Europe until about five hundred years ago, and if the Chinese, the Japanese, and the people of India ever possessed the art they kept it to themselves and made but little use of it.

CHAPTER V.

MEDIÆVAL AND EARLY MODERN PROCESSES IN THE MANUFACTURE OF IRON.

From the first to the eighth century of the Christian era the history of the manufacture of iron in all European countries is greatly obscured, and the processes which were in operation can not be described. In Asia and Africa the art had previously received less and less attention through the gradual transfer of political power and of civilization to the northern shores of the Mediterranean. But Greece, which had received much of this power and had absorbed most of this civilization, had in turn surrendered her leadership to Rome, and in the fifth century after Christ Rome herself fell before the northern barbarians. Except in Spain, where the Visigoths established a powerful empire in the fifth century, under which the arts of ancient civilization were encouraged, the iron industry is nowhere throughout Europe known to have flourished from the time when Rome commenced her final struggle with the northern invaders down to about the beginning of the eighth century. At this time we begin to hear of the iron industry taking a fresh start in many European countries, experiencing what in modern phrase we term a revival. And with this revival we hear authentically for the first time of the wolf furnace, or *stückofen*, in Austria, Bohemia, Germany, Belgium, and other Continental countries.

The wolf furnace, or *stückofen*, was a high bloomary, and as such was simply an enlargement of the primitive low bloomaries or forges. Percy says that the *stückofen* "is only a Catalan furnace extended upwards in the form of a quadrangular or circular shaft. The Germans call it *stück* or *wolf's ofen* because the large metallic mass which is extracted from the bottom is termed *stück* or *wolf*." The word "bloom" properly expresses the English equivalent of both words. Overman says that these furnaces or bloomaries, of which there yet remain a few in Hungary and Spain, are generally from 10 to 16 feet high, 2 feet wide at the top and bottom, and about 5 feet wide

at the widest part. The early wolf furnaces were, however, not more than 10 feet high. An opening in the front, about 2 feet square, called the breast, was kept open until the furnace was heated, when, coincidently with the closing of the breast with brick, the ore and charcoal were thrown into the furnace and the blast was applied from "at least two bellows and nozzles, both on the same side." The product was a mass, or salamander, of mixed iron and steel, which was taken out of the breast and reduced under the tilt-hammer to blooms, and under smaller hammers to bars and other forms. The salamander, which usually weighed from 400 to 700 pounds, was first cut into two nearly equal parts, which were called *stücke*. At Eisenerz, in Austria, as stated by Jars, quoted by Percy, "the lump was first cut half through in the centre with hatchets by two men, each having one. It was afterwards completely divided by means of wedges and large hammers." The annual production of a wolf furnace was from 100 to 150 tons. Overman further says: "By this method good iron as well as steel is always furnished; in fact, the salamander consists of a mixture of iron and steel; of the latter skillful workmen may save a considerable amount. The blooms are a mixture of fibrous iron, steel, and cast iron. The latter flows into the bottom of the forge fire, in which the blooms are reheated, and is then converted into bar iron by the same method adopted to convert common pig iron. If the steel is not sufficiently separated it is worked along with the iron." At Solling, in Carinthia, a wolf furnace was erected in 1775 which was provided with two common bellows worked by water-wheels, each bellows being 8 feet long and 3¾ feet broad.

While there can be no doubt that the earliest wolf furnaces were blown with leather bellows, it is not known when water-power was first used in producing the blast and in operating the hammers. Water-power for grinding grain is said by Knight to have been used about the beginning of the Christian era. In Agricola's *De Re Metallica*, printed at Basle in 1556, are numerous engravings which show that large tilt-hammers and leather bellows, operated by water-power, were used in the manufacture of iron and steel in Saxony at that time. In Flower's *History of the Trade in Tin* will be found two very interesting illustrations of the manner in

which the bellows and tilt-hammer were operated by water-power in France in 1714. Prior to the introduction of water-power, bellows were doubtless chiefly operated by the feet or hands. Horse-power has been used for the same purpose since the introduction of water-power, and was probably so used before that period.

The osmund furnace, which is said by Percy to have been intermediate between the Catalan forge and the *stückofen*, but which may properly be described as a small *stückofen*, was formerly in use in Northern Europe, principally for smelting bog or lake ore, and it is still in use in Finland. It is said by Karsten, in his *Grundriss der Metallurgie*, printed at Breslau in 1818, to have been in use in Norway and Sweden at that date, but its use in these countries has now been abandoned. It derived its name from the Swedish word *osmund*, "which was applied to the bloom produced in this kind of furnace." Percy reproduces from Swedish sources two drawings of an osmund furnace, from which it would appear that it was about 7 feet high, rectangular in shape, with an opening or breast near the bottom similar to that of the *stückofen*, and was blown through one tuyere with two ordinary blacksmith's bellows, worked with treadles by a woman's feet. The ore used in Sweden was first calcined before being placed in the furnace, wood being used for calcining and charcoal for smelting. The product was good malleable iron, which was taken out of the breast in a lump, or *osmund*. Not more than 1½ tons of iron could be produced in this furnace in a week.

Percy says: "The transition from the old bloomary to the modern blast furnace was very gradual, and the *stückofen* is the final development of the furnaces in which iron in the malleable state was produced direct from the ore. By increasing the dimensions of the *stückofen*, especially its height, the conditions favorable to the formation of cast iron are obtained; and, indeed, in the *stückofen* cast iron was generally, if not always, produced in greater or less degree, to the annoyance of the smelter."

As stated by Percy, the *stückofen* itself was gradually superseded by the blast furnace, the first furnace which replaced the *stückofen* being the *blauofen*, or blow oven. He says that "originally there was no essential difference between them,

these names being applied according to the nature of the metal which they yielded, and not in consequence of difference of construction"—malleable iron being obtained with much less charcoal than was used when cast iron was desired. "When the *blauofen* was used as a *stückofen* it was only necessary to make an opening in the fore part of the hearth large enough for the extraction of the lump. One essential condition in working the furnace as a *stückofen* was to allow the slag free escape during the process, so that the lump of iron accumulating in the hearth might never be covered with slag, and so be protected from the action of the blast." The *blauofen*, which is not entirely extinct on the Continent, dates from about the beginning of the fourteenth century. The *flussofen* was substantially the same furnace as the *blauofen*. "Blast furnace" may properly be substituted for either term. *Hochofen* was another German name that was applied to the blast furnace, and it is still retained. Karsten says that in 1818 the *stückofen* was no longer used in Germany, except at Schmalkalden, which is a town in Prussia. He says, however, that many *stücköfen* were then in use in Hungary.

We have already stated that the blast furnace is supposed to have originated in the Rhine provinces about the beginning of the fourteenth century. We are unable to trace its existence to an earlier date than 1340, when the furnace at Marche les Dames, in Belgium, was built. It was many years, however, before the blast furnace was generally introduced on the Continent or in England. It was not introduced into Saxony until 1550, and Agricola, who was a native of Saxony, does not describe it in his curious and valuable work, which was first printed in 1530, but he describes the *stückofen* and the forges for refining iron and producing steel. Percy says that Agricola "appears to have been acquainted with cast iron," but this, as has already been shown, could have been produced by the *stückofen*.

The Continental nations of Europe are entitled to the credit of having fully developed the blast furnace from the primitive method of producing iron in the bloomary or Catalan forge. The virtual perfection of the blast furnace by the Germans, the Belgians, and the French in the fifteenth and sixteenth centuries marked a great advance in the art of man-

ufacturing iron, and greatly enlarged the uses to which iron could be applied. The nations which have been mentioned were also the first among modern nations to cast iron in moulds, the Germans and French being especially noted at an early day for the artistic excellence of their iron castings. The blacksmiths of Germany, France, Belgium, Italy, and Spain, as well as of England, greatly excelled in the manufacture of steel swords, iron armor, iron railings, iron gates, hinges, knockers, etc., and iron decorations of all kinds, in the twelfth and succeeding centuries.

The Catalan forge, with its modifications, continued to be used during the period covered by the development of the blast furnace, and, as has already been said, it is still in use in many countries, being especially adapted to the conversion of pure ores into malleable iron of superior quality. A modification of the Catalan forge, called the German bloomary, consisting more, however, in the treatment of the ore than in the construction of the hearth and its connections, was long very popular in Germany and in the United States, but it has now been almost entirely abandoned in both these countries. After the commencement of the manufacture of cast or pig iron, refinery forges suited to the conversion of this product into wrought iron became necessary, but they did not differ in any essential details of construction or application from the Catalan forge and the refinery forges which had previously been found necessary in connection with the *stückofen*. Refinery forges have sometimes been called bloomaries, because pig iron is by them first reduced to a bloom before it is still further refined; but properly speaking a bloomary is a forge that converts iron ore into wrought iron by the direct process. The word "bloomary" is of Anglo-Saxon origin, the Anglo-Saxon word *bloma*, from which it is derived, meaning a mass, or lump. In *Doomsday-Book* the expression *bloma ferri* occurs several times.

In *The Forest of Dean* Nicholls quotes a most interesting description of the blast furnaces and refinery forges of England in the latter part of the seventeenth century. It has already been mentioned that the blast furnace was introduced into England from the Continent about the beginning of the fifteenth century. The author, after recording events which

occurred on April 27, 1680, a little more than two hundred years ago, says: "The mode then in use of operating upon the iron ore as described in MS. by Dr. Parsons will be found in Appendix No. 5." This description is as follows:

After they have provided their ore their first work is to calcine it, which is done in kilns, much after the fashion of our ordinary lime kilns; these they fill up to the top with coal and ore until it be full, and so, putting fire to the bottom, they let it burn till the coal be wasted, and then renew the kilns with fresh ore and coal. This is done without any infusion of mettal, and serves to consume the more drossy part of the ore, and to make it fryable, supplying the beating and washing, which are to no other mettals; from hence they carry it to their furnaces, which are built of brick and stone, about 24 foot square on the outside, and near 30 foot in height within, and not over 8 or 10 foot over where it is the widest, which is about the middle, the top and bottom having a narrow compass, much like the form of an egg. Behind the furnace are placed two high pair of bellows, whose noses meet at a little hole near the bottom; these are compressed together by certain buttons placed on the axis of a very large wheel, which is turned round by water, in the manner of an overshot mill. As soon as these buttons are slid off, the bellows are raised again by a counterpoise of weights, whereby they are made to play alternately, the one giving its blast while the other is rising.

At first they fill these furnaces with ore and cinder intermixt with fuel, which in these works is always charcoal, laying them hollow, at the bottom, that they may the more easily take fire; but after they are once kindled the materials run together into an hard cake or lump, which is sustained by the furnace, and through this the mettal as it runs trickles down the receivers, which are placed at the bottom, where there is a passage open, by which they take away the scum and dross, and let out their mettal as they see occasion. Before the mouth of the furnace lyeth a great bed of sand, where they make furrows of the fashion they desire to cast their iron. Into these, when the receivers are full, they let in their mettal, which is made so very fluid by the violence of the fire that it not only runs to a considerable distance, but stands afterwards boiling a great while. After these furnaces are once at work they keep them constantly employed for many months together, never suffering the fire to slacken night or day, but still supplying the waste of fuel and other materials with fresh, poured in at the top.

Several attempts have been made to bring in the use of the sea coal in these workes instead of charcoal; the former being to be had at an easy rate, the latter not without a great expence, but hitherto they have proved ineffectual, the workmen finding by experience that a sea-coal fire, how vehement soever, will not penetrate the most fixed parts of the ore, by which means they leave much of the mettal behind them unmelted.

From these furnaces they bring the sows and piggs of iron, as they call them, to their forges; these are two sorts, though they stood together under the same roof; one they call their finery, and the other chafers; both of them are upon hearths, upon which they place great heaps of sea coal, and

behind them bellows like those of the furnaces, but nothing near so large. In such finerys they first put their piggs of iron, placing three or four of them together behind the fire, with a little of one end thrust into it, where softening by degrees they stir and work them with long barrs of iron till the mettal runs together in a round masse or lump, which they call an half bloome: this they take out, and, giving it a few strokes with their sledges, they carry it to a great weighty hammer, raised likewise by the motion of a water-wheel, where, applying it dexterously to the blows, they presently beat it into a thick short square; this they put into the finery again, and, heating it red hot, they work it under the same hammer till it comes to the shape of a bar in the middle, with two square knobs in the ends; last of all they give it other heatings in the chaffers, [chafery,] and more workings under the hammer, till they have brought their iron into barrs of several shapes, in which fashion they expose them to sale.

All their principal iron undergoes the aforementioned preparations, yet for several other purposes, as for backs of chimneys, hearths of ovens, and the like, they have a sort of cast iron, which they take out of the receivers of the furnace, so soon as it is melted, in great ladles, and pour it into the moulds of fine sand in like manner as they do cast brass and softer mettals; but this sort of iron is so very brittle that, being heated, with one blow of the hammer it breaks all to pieces.

John Ray, the naturalist, writing a little earlier, in 1672, has also fully described, in two papers appended to his *Collection of English Words*, the blast furnaces and forges which existed in England in his day. "This account of the whole process of the iron work," he says, "I had from one of the chief ironmasters of Sussex, my honored friend, Walter Burrell, Esq., of Cuckfield, deceased." We give below a literal copy of this description.

THE MANNER OF THE IRON WORK AT THE FURNACE.

The iron mine lies sometimes deeper, sometimes shallower, in the earth, from four to forty [feet] and upward. There are several sorts of mine, some hard, some gentle, some rich, some coarser. The ironmasters always mix different sorts of mine together, otherwise they will not melt to advantage. When the mine is brought in they take small-coal [charcoal] and lay a row of it, and upon that a row of mine, and so alternately S.S.S., one above another, and, setting the coals on fire, therewith burn the mine. The use of this burning is to mollify it, that so it may be broke in small pieces; otherwise if it should be put into the furnace as it comes out of the earth it would not melt, but come away whole. Care also must be taken that it be not too much burned, for then it will *loop, i. e.*, melt and run together in a mass. After it is burnt they beat it into small pieces with an iron sledge, and then put it into the furnace, (which is before charged with coals,) casting it upon the top of the coals, where it melts and falls into the hearth, in the space of about twelve hours, more or less, and then it runs into a *sow*.

The hearth, or bottom of the furnace, is made of sandstone, and the sides round, to the height of a yard, or thereabout; the rest of the furnace is lined up to the top with brick. When they begin upon a new furnace they put fire for a day or two before they begin to blow. Then they blow gently and encrease by degrees 'till they come to the height in ten weeks or more. Every six days they call a *founday*, in which space they make eight tun of iron, if you divide the whole sum of iron made by the foundays: for at first they make less in a founday, at last more. The hearth by the force of the fire, continually blown, grows wider and wider, so that at first it contains so much as will make a sow of six or seven hundred pound weight; at last it will contain so much as will make a sow of two thousand pound. The lesser pieces, of one thousand pound, or under, they call pigs.

Of twenty-four loads of coals they expect eight tun of sows: to every load of coals, which consists of eleven quarters, they put a load of mine, which contains eighteen bushels. A hearth ordinarily, if made of good stone, will last forty foundays, that is, forty weeks, during which time the fire is never let go out. They never blow twice upon one hearth, though they go upon it not above five or six foundays. The cinder, like scum, swims upon the melted metal in the hearth, and is let out once or twice before a sow is cast.

THE MANNER OF WORKING THE IRON AT THE FORGE OR HAMMER.

In every forge or *hammer* there are two fires at least; the one they call the *finery*, the other the *chafery*. At the finery, by the working of the hammer, they bring it into *blooms* and *anconies*, thus:

The sow they, at first, roll into the fire, and melt off a piece of about three-fourths of a hundred-weight, which, so soon as it is broken off, is called a *loop*. This *loop* they take out with their shingling-tongs, and beat it with iron sledges upon an iron plate near the fire, that so it may not fall in pieces, but be in a capacity to be carried under the hammer. Under which they, then removing it, and drawing a little water, beat it with the hammer very gently, which forces cinder and dross out of the matter; afterwards, by degrees, drawing more water, they beat it thicker and stronger 'till they bring it to a *bloom*, which is a four-square mass of about two feet long. This operation they call *shingling the loop*. This done, they immediately return it to the finery again, and, after two or three heats and workings, they bring it to an *ancony*, the figure whereof is, in the middle, a bar about three feet long, of that shape they intend the whole bar to be made of it; at both ends a square piece left rough to be wrought at the chafery.

Note. At the finery three load of the biggest coals go to make one tun of iron. At the chafery they only draw out the two ends suitable to what was drawn out at the finery in the middle, and so finish the bar.

Note 1. One load of the smaller coals will draw out one tun of iron at the chafery. 2. They expect that one man and a boy at the finery should make two tuns of iron in a week: two men at the chafery should take up, *i. e.*, make or work, five or six tun in a week. 3. If into the hearth where they work the iron sows (whether in the chafery or the finery) you cast upon the iron a piece of brass it will hinder the metal from working, causing it to spatter about, so that it can not be brought into a solid piece.

John Houghton, in his *Husbandry and Trade Improved*, printed in 1697, calls the square first made a half bloom, and the bar with the two knobs a bloom, the greater end being called the mocket head, and the smaller the ancony end. At the third heat, there being five heats in all, the ancony end was reduced to a bar, and at the fourth and fifth heats the mocket head was also reduced.

After coke came into general use in the blast furnaces of Great Britain the method of refining iron which is above described was somewhat changed in that country in details but not in principle. On the Continent, however, where charcoal continued to be the only fuel used, there was no change in the method of refining iron until the puddling furnace was introduced, after the beginning of the present century, in company with the rolling mill for rolling bar iron. The puddling furnace was introduced into Sweden, at Skebo, and into France, at Fourchambault, about 1820; into Rhenish Prussia about 1830; into Westphalia and Upper Silesia about 1835; and in Siegen and the Hartz mountains about 1840.

The English blast furnaces and refinery forges that have been described were counterparts of Continental furnaces and forges of the same period. On the Continent, as well as in England, as described by Dr. Parsons, various castings were made direct from the furnace, which for this reason was often called a "foundry." These castings, in addition to the articles mentioned by Dr. Parsons, embraced such domestic utensils of iron as pots, kettles, skillets, andirons, stoves, etc.

Wooden bellows, or "tubs," as a substitute for leather bellows in connection with blast furnaces and forges, do not appear to have been used in England in the seventeenth century, although said to have been invented by Hans Lobsinger, of Nuremberg, in Germany, about 1550. They were certainly used in Germany eighty years later, in 1630, and in various parts of Great Britain in the eighteenth century. In 1750 leather bellows were used to blow the charcoal furnaces in Monmouthshire. As late as 1809 leather bellows, 22 feet long and having oak planks two inches thick, were still used in blowing some Scotch furnaces. Both leather and wooden bellows have been used in blowing the furnaces and forges of the United States, and the use of wooden bellows had not been

wholly abandoned in this country as late as the spring of 1884.

The *trompe*, or water-blast, is said to have been invented in Italy in 1640. Its use has been mainly confined to some of the charcoal furnaces and Catalan forges of Germany, France, Spain, and Italy. It appears never to have been introduced into any part of Great Britain. Although now generally abandoned, it may still be found supplying the blast for a few forges in Europe and in the southern part of the United States. Professor J. P. Lesley thus described, in 1858, in his *Iron Manufacturer's Guide*, the water-blast which was then in use in the Southern States in connection with Catalan forges:

> The use of the water-blast is all but universal. It consists of a box, say 5 by 2½ by 1½ feet deep, nearly immersed in the stream, directly underneath the forebay or flume. The water rushes down into its upper end from the forebay through a wooden pipe, say 8 inches square, separated in two by a space of an inch or two, as if the two joints of a stove-pipe had parted that much. Into this slit air is sucked by the falling water and driven out through another 3-inch tube at the lower end. Inside the box, and parallel with its lid, a plank called the "spatter-board" is set a few inches below the first tube. The water escapes from a hole under the water-level at the lower end of the box. This apparatus gives a cold, damp blast, with a great waste of water, but one that is very uniform.

The origin of the rolling mill for rolling iron into bars or plates is not wholly free from doubt. Scrivenor, quoting from Coxe's *Tour in Monmouthshire*, says that "in the early part of the eighteenth century John Hanbury invented the method of rolling iron plates by means of cylinders." Flower, alluding to the manufacture of tin plates at Pontypool, says that "the discovery of sheet-iron rolling followed in 1728, an invention claimed alike by John Payne and by Major Hanbury, and it was in a great measure owing to this improvement that we were enabled to turn the tables upon Germany. The tinmen were greatly delighted with the English plates; the color was better, and the rolled plates were found to be more pliable than the foreign ones which were hammered." The following statement is taken from Dr. Ure's *Dictionary of the Arts*: "In 1728 John Payne invented a process for rolling iron. This seems to have at once led to the use of the flat or sheet rolls for the manufacture of iron for tin plates; but it is very remarkable that no further progress was made in this discovery of rolling iron until 1783, when Henry Cort introduced the

grooved rolls." Percy says: "With respect to the invention of grooved rolls it has been maintained that Cort's claim is invalidated by the old patent granted to John Payne in 1728." It is certain, however, that even plain rolls did not come into general use until the rolling mill had been perfected by Cort—the refinery fire, the leather and wooden bellows, the tilting-hammer, and the water-wheel still holding their place in the manufacture of finished iron on the Continent and in England.

Dr. Johnson, in the diary of his tour in Wales and Monmouthshire in 1774, says that at an iron works he saw "round bars formed by a notched hammer and anvil," and that at a copper works he saw "a plate of copper put hot between steel rollers and spread thin." The whole passage in the diary is as follows:

Wednesday, August 3 [1774]. * * * We went in the coach to Holywell. * * * We there saw a brass work, where the *lapis calaminaris* is gathered, broken, washed from the earth and the lead, though how the lead was separated I did not see; then calcined, afterwards ground fine, and then mixed by fire with copper. We saw several strong fires with melting pots, but the construction of the fire-places I did not learn. At a copper work, which receives its pigs of copper, I think, from Warrington, we saw a plate of copper put hot between steel rollers and spread thin. I know not whether the upper roller was set to a certain distance, as I suppose, or acted only by its weight. At an iron works I saw round bars formed by a notched hammer and anvil. There I saw a bar of about half an inch or more square cut with shears worked by water, and then beaten hot into a thinner bar. The hammers, all worked as they were by water, acting upon small bodies, moved very quickly, as quick as by the hand. I then saw wire drawn and gave a shilling.

We find by an examination of English patents that, on November 21, 1728, John Payne, an Englishman, obtained a patent for various improvements in the manufacture of iron, which consisted in part in the application of certain ashes, salt, etc., to pig or sow iron while in the refinery fire, "which will render the same into a state of malleability, as to bear the stroke of the hammer, to draw it into barrs or other forms att the pleasure of the workman, and those or other barrs being heated in the said melted ingredients in a long hott arch or cavern, as hereafter is described; and those or other barrs are to pass between two large mettall rowlers, (which have proper notches or furrows upon their surfass,) by the force of my engine hereafter described, or other power, into such

shapes and forms as shall be required." Plain rolls for rolling sheet iron for tin plates are not referred to. Other patents were subsequently granted in England for the invention of rolls of various forms for rolling bar iron. In 1759 a patent was granted to Thomas Blockley for rolls which "are to be turned and formed of the requisite shape so as to shape the article as intended." In 1779 a patent was granted to William Bell for rolls which "have designs sunk in their surfaces."

In John Houghton's *Husbandry and Trade Improved*, printed in 1697, he speaks of slitting and rolling mills as "late improvements." This is the earliest reference we have found to a rolling mill in connection with a slitting mill. Such use of a rolling mill would naturally precede its use for any other purpose in connection with the manufacture of iron. In Flower's *History of the Trade in Tin* the manufacture of tin plates at Mansvaux, in Alsace, in 1714, is fully described, and it is noticeable that the sheet iron then used was hammered. This description, which is illustrated, sustains the claim that either John Payne or Major Hanbury was the first person to roll sheet iron fourteen years later, in 1728, an innovation which undoubtedly grew out of the use of the rolling mill in the manufacture of nail plates as early as 1697, as recorded by John Houghton, and which probably followed Payne's invention for the use of grooved rolls.

We quote below John Houghton's statement concerning the rolling mill just as we find it under the date of Friday, October 22, 1697, in Bradley's edition of *Husbandry and Trade Improved*, printed at London in 1727. After describing "how the sows and pigs of iron are prepared for bars and drawn into such" in the refinery forges, "which are of two sorts," the "finery" and the "chafery," he tells us in the following words how the bars are converted into nail rods.

> Whereof those they intend to be cut into rods are carried to the *slitting mills*, where they first break, or cut them cold, with the force of one of the wheels, into short lengths; then they are put into a furnace to be heated red-hot to a good height, and then brought singly to the rollers, by which they are drawn even, and to a greater length; after this another workman takes them whilst hot, and puts them through the *cutters*, which are of divers sizes, and may be put on or off according to pleasure. Then another lays them straight also whilst hot, and when cold binds them also into faggots, and then they are fit for sale.

And thus I have given an account of the *iron works* of *Staffordshire* from the oar to the slitting mills, as they are now exercised in their perfection, the improvement whereof we shall find very great if we look back upon the methods of our ancestors that made iron in *foot-blasts* or *bloomeries*, by means of treading the *bellows*, by which way they could make but one little lump or *bloom* of iron in a day, not a hundred weight, leaving as much iron in the *slag* as they got out. Whereas now they will make two or three tons of cast iron in twenty-four hours; leaving the slag so poor that the founders can not melt them again to profit, not to mention again the vast advantage they have from the new invention of *slitting mills* for cutting their bars into rods, above what they had antiently.

Houghton's whole statement, from which the above extract is taken, is entitled by him "a note of late improvements."

A letter of inquiry to Professor Richard Åkerman, of the School of Mines, Stockholm, Sweden, requesting such information as might be in his possession concerning the origin of the slitting mill and the rolling mill, was answered as follows:

That slitting mills were in use before rolling mills is most probable and nearly certain. At the beginning of this century there could still be found slitting mills in which hammered but not rolled iron was slit. But all slitting mills were not made on the principle of rolling mills; many of them more resembled scissors.

The first publication about rolling mills in this country which I have seen or know about is *De Ferro*, by Emanuel Swedenborg, which was printed in 1734. Swedenborg speaks both about slitting machines on the principle of scissors, cutting three rods at a time, and about slitting mills in connection with rolling mills. He describes slitting mills in Sweden, in the Liége district of Belgium, in Germany, and in England; but he does not say a single word about where he thinks they originated. *Swedenborg does not say anything about grooved rolls.* In fact he only describes rolling mills in connection with slitting mills. On page 253 he speaks about Swedish rolling mills at Wedewåg, Avesta, and Stjernsund.

On the contrary, Christopher Polhem, in his *Patriotiska Testamente*, which was printed in 1761, ten years after his death, when he was 90 years old, speaks about rolling mills as such, both for plates and bar iron. He says, in chapter 14, "much time and labor can be saved by good rolling mills, because a rolling mill can produce 10 to 20 and still more bars at the same time which is wanted to tilt only one bar with the hammer. Thus very thin bar iron can be made which is useful for hoops and mountings of several kinds. Steel also can be rolled out for knife blades, etc., which easily can be finished by the blacksmith. The rolls can be so made that the knife-steel becomes broad and thin on both sides, or gets the same shape as blades of common swords, and these can be cut lengthwise in two parts, thus giving suitable material for knives, etc. Rolls also can be made for producing quadrangular, round, and half-round bars, not only for iron but also for steel, as for all kinds of files which easily can be finished by the blacksmith."

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That slitting mills were in use before rolling mills is most probable and nearly certain. At the beginning of this century there could still be found slitting mills in which hammered but not rolled iron was slit. But all slitting mills were not made on the principle of rolling mills; many of them more resembled scissors.

The first publication about rolling mills in this country which I have seen or know about is *De Ferro*, by Emanuel Swedenborg, which was printed in 1734. Swedenborg speaks both about slitting machines on the principle of scissors, cutting three rods at a time, and about slitting mills in connection with rolling mills. He describes slitting mills in Sweden, in the Liége district of Belgium, in Germany, and in England; but he does not say a single word about where he thinks they originated. *Swedenborg does not say anything about grooved rolls.* In fact he only describes rolling mills in connection with slitting mills. On page 253 he speaks about Swedish rolling mills at Wedewåg, Avesta, and Stjernsund.

On the contrary, Christopher Polhem, in his *Patriotiska Testamente*, which was printed in 1761, ten years after his death, when he was 90 years old, speaks about rolling mills as such, both for plates and bar iron. He says, in chapter 14, "much time and labor can be saved by good rolling mills, because a rolling mill can produce 10 to 20 and still more bars at the same time which is wanted to tilt only one bar with the hammer. Thus very thin bar iron can be made which is useful for hoops and mountings of several kinds. Steel also can be rolled out for knife blades, etc., which easily can be finished by the blacksmith. The rolls can be so made that the knife-steel becomes broad and thin on both sides, or gets the same shape as blades of common swords, and these can be cut lengthwise in two parts, thus giving suitable material for knives, etc. Rolls also can be made for producing quadrangular, round, and half-round bars, not only for iron but also for steel, as for all kinds of files which easily can be finished by the blacksmith."

In the next chapter Polhem describes the manner of making wrought-iron rolls covered with steel. Further on in the same chapter he speaks of rolls for rolling sheets: "As such rolls commonly have a length of three quarters, it follows that their diameter must be rather large; but, as thick rolls in comparison with slender ones have only a small effect in stretching, broad sheets can not be rolled. If not, two slender wrought-iron rolls are put between the two thick cast-iron rolls, which prevent the slender rolls from yielding. Such rolls I have put up at Stjernsund after having tried their effect by experiments on a small scale." After mentioning economical difficulties, in consequence of which he was obliged to leave unused both this and other expensive machines, he concludes with the following words: "Yet I willingly grant to others, who perhaps will live during more happy times, what I have not got opportunity to use for myself."

Polhem says nothing about the time when he put up the said rolling mill, but, if you remember that he was born 1661 and died 1751, it seems probable that it must have been during the first decades of the eighteenth century. Christopher Polhem was the greatest mechanical genius Sweden has ever produced, but whether he was the very first inventor of rolling mills it is impossible for me to say. At any rate he ought to be mentioned among the inventors of rolling mills. In fact, Polhem must be said to be the real inventor of what you call the Lauth rolling mill. The only difference is that Polhem used four rolls above each other, two small between two large ones.

Gabriel Polhem, a son of Christopher Polhem, in the *Transactions of the Royal Swedish Academy of Sciences* for 1740, gives a description of a rolling mill, "the invention of my father," which he (Gabriel Polhem) put up at the mint in Cassel, Germany. He says that the officers of the mint did not believe that a rolling mill could be of any use for the mint, but he was in 1733 ordered by King Frederick to put it up, and it proved most useful for getting more uniform thickness and weight of the coins. From this and other expressions in the description it is quite clear that the said rolling mill was the very first put up at any mint, but not long afterwards a rolling mill also was put up at the Swedish mint.

This communication from Professor Åkerman is a very important one, especially in its reference to the use of the rolling mill for rolling "plates and bar iron" as early as 1751, the year of the death of Christopher Polhem. It proves that plate and bar iron were rolled long before Cort's day, but not until after the rolling mill had been used as early as 1697 in connection with the slitting mill, as recorded by John Houghton, nor until after the invention of sheet-iron rolling in 1728, with which the names of Payne and Hanbury are associated. The germ of the great invention by which iron and steel are rolled into so many and into such infinitely small and wonderfully large shapes in our day undoubtedly originated with

the man who added the rolling mill to the slitting mill, and after a laborious investigation we regret that we can not give his name nor definitely fix the date of his invention. Cort, however, is entitled to the credit of so improving upon all previous suggestions that the rolling mill in his hands became a successful invention for the numerous and important purposes to which it is now applied.

The methods of producing steel which were in use before Huntsman succeeded in making crucible steel near Sheffield, about 1750, to which event we have referred in the chapter relating to Great Britain, were substantially only three in number. The first method was either closely allied to or was wholly identical with the direct or Catalan process for producing iron, the product being variously known as natural steel, raw steel, or German steel. The second method was the Indian process for converting small pieces of bar iron into steel in crucibles, the product being wootz, or Indian steel. The third method was the cementation process, in which bars of the best iron were carbonized by being heated in contact with charcoal, blister steel and shear steel being the result. Steel produced by the cementation process is also known as German steel, because much attention was long given to its production by Germany. All of these methods are yet in use. The first method, which requires the use of a forge, and which was originally applied to iron ore but is now applied to pig iron, is most observed in Germany and Austria. In Styria the finest tool steel is produced by it.

Percy says of the cementation process, by which until in recent years much of the steel of Europe and America was produced: "This is an old process, but little is known of its history. According to Beckmann there is no allusion to it in the writings of the ancients. It was well described by Reaumur in 1722, in his admirable treatise on the art of converting bar iron into steel." Landrin says: "Germany is also the first country where it was proposed to cement iron. Thence this art came to France, and was introduced at Newcastle-on-Tyne long before it was known at Sheffield, the present centre of that fabrication." Landrin's compliment to Germany is doubtless well deserved. Indeed, Germany is entitled to rank as one of the most prominent of all the iron-making nations

ever since the revival of the iron industry in Europe about the beginning of the eighth century.

With the exception of the blast furnace, which was slowly developed from the high bloomary, and of the cementation process for producing steel, which doubtless originated during the period when the blast furnace was developed, no important improvement in the manufacture of iron and steel occurred from the revival of the iron industry in Europe about the beginning of the eighth century until we reach the series of improvements and inventions in the eighteenth century which have already been fully noticed—a period of a thousand years. It is just one hundred years since Henry Cort prominently brought the rolling mill and the puddling furnace to the attention of the iron-making world, and scarcely a hundred and fifty years since coke was first used in the blast furnace and steel was first made in England in crucibles.

Since Huntsman's invention, which still gives us our best steel, there have been many other improvements in the manufacture of steel, and more recently there has been a very great relative increase in its production and use as compared with iron, until it has become a hackneyed expression that this is the age of steel. While this is true in the sense that steel is replacing iron, it is well to remember that the ancients made steel of excellent quality, and that the art of manufacturing it was never lost and has never been neglected. The swords of Damascus and the blades of Toledo bear witness to the skill in the manufacture of steel which was possessed by the older nations of both Asia and Europe. German steel was celebrated for its excellence during the middle ages, and steel of the same name and made by the same processes still occupies an honorable place among metallurgical products. Even Huntsman's invention of the art of making the finest quality of steel in crucibles, while meritorious in itself, was but the reproduction and amplification in a modern age of a process for manufacturing steel of equal quality which was known to the people of India thousands of years ago.

The ancient and the early European processes for the manufacture of both iron and steel do not compare unfavorably with those of modern times in the quality of the products they yielded. Modern processes excel those which they have

replaced more in the uniformity and quantity of their products than in their quality. The Germans once had a furnace for making small quantities of iron by laborious manual labor, one name for which, *bauernofen*, indicates that it was used by farmers when they were not engaged in cultivating or securing their crops. This furnace was the *stückofen*, but doubtless in its modified form, the osmund furnace. In the present age mechanical skill of the highest order unites with the subtle operations of the chemist to produce iron and steel in such quantities and with such uniformity of product as to amaze not only the modern farmer but also the student of history, the political economist, the practical statesman, and the man of all wisdom.

CHAPTER VI.

FIRST ATTEMPT BY EUROPEANS TO MANUFACTURE IRON IN THE UNITED STATES.

Having traced in preceding pages, as briefly as the importance of the subject would permit, the early history of the manufacture of iron in the older countries of the world, especially in Great Britain, our mother country in this great industry as well as in national life, and in language, laws, literature, and religion, we now cross the Atlantic to the shores of the New World, and to that part of it which comprises the United States. In no other part of the American continent has the manufacture of iron ever risen to the dignity of a great national industry; and only in Canada, of all the political divisions of North or South America outside of the United States, has a serious effort ever been made to develop native iron resources. This is a remarkable fact, the explanation of which is mainly found in a study of national characteristics, the gift of iron ore and of fuel to smelt it having been denied to very few of our territorial neighbors. It is a further striking fact that in our own country the iron industry has received its principal development in the Northern States. Indeed, it is only in northern latitudes in both hemispheres, and only in the central part of the north temperate zone, that iron is made in large or even in noticeable quantities. This fact is only in part due to geological reasons; climate and race tendencies have had much to do with stimulating the metallurgical as well as all other industries in the belt of the earth's surface alluded to, and which may well be called the iron-making belt.

It would not be profitable to inquire minutely whether the mound-builders or other aboriginal inhabitants of the United States, or the aboriginal inhabitants of any other part of the American continent, possessed a knowledge of the use and consequently of the manufacture of iron. It may be assumed that it has not been proved that they possessed this knowledge. Antiquarians have not neglected a subject of so much

importance, but thus far their researches have produced only negative results. Rude hatchets and other small implements of iron have been found in situations which give color to the theory that they may have been of aboriginal origin, but the weight of much concurrent testimony is strongly against this supposition. Foster, in his *Prehistoric Races of the United States of America*, says that "no implement of iron has been found in connection with the ancient civilizations of America." He fully establishes the fact that the mound-builders manufactured copper into various domestic and warlike implements, but adds that the Indians of North America did not use copper in any form, although those of Central and South America did. Prescott says that the inhabitants of Mexico and Peru, who were, at the time of the conquest, the most advanced in all the arts of civilization of the immediate predecessors of the white race in North and South America, were unacquainted with the use of iron, copper serving them as a substitute. Our North American Indians were certainly unacquainted with the use of iron when the English, the Dutch, and other Europeans first landed on the Atlantic coast. Cotton Mather, in his *Life of Eliot*, says that among the Indians of New England "stone was used, instead of metal, for their tools," and other writers bear like testimony concerning all our Indians.

In the absence of positive information concerning the use of iron by any of the aboriginal inhabitants of America, the interesting fact may be parenthetically stated that iron is now made in Cherokee county, in the western part of North Carolina, by some members of the remnant of a band of Cherokee Indians. They use the primitive Catalan forge, which was introduced into North Carolina by the early white settlers, and from the iron so produced they make various tools and implements.

North Carolina first gave to Europeans the knowledge that iron ore existed within the limits of the United States. The discovery was made in 1585 by the expedition fitted out by Sir Walter Raleigh, and commanded by Ralph Lane, which made, in that year, on Roanoke Island, the first attempt to plant an English settlement on the Atlantic coast. Bishop, in his *History of American Manufactures*, says that "Lane and his men explored the country along the Roanoke and on both

sides from Elizabeth river to the Neuse." Thomas Hariot, the historian of the colony, and the servant of Sir Walter Raleigh, says that "in two places of the countrey specially, one about foure score and the other sixe score miles from the fort or place where wee dwelt, wee founde neere the water side the ground to be rockie, which, by the triall of a minerall man, was founde to hold iron richly. It is founde in manie places of the countrey else. I know nothing to the contrarie but that it maie bee allowed for a good marchantable commoditie, considering there the small charge for the labour and feeding of men; the infinite store of wood; the want of wood and deerenesse thereof in England; and the necessity of ballasting of shippes." But no attempt was made to utilize this discovery, as the colonists were in search of gold and not iron. In 1586 they quarreled with the Indians and returned to England. A permanent settlement in North Carolina was not effected until many years afterward. Iron ore was not mined in North Carolina nor was iron made within its boundaries until after many of the other colonies had commenced to make iron.

In 1607 the first permanent English colony in the New World was founded at Jamestown, in Virginia, by the Virginia Company of London, and on the 10th of April in the following year, 1608, the company's ship, commanded by Captain Christopher Newport, sailed from Jamestown, loaded with iron ore, sassafras, cedar posts, and walnut boards, and on the 20th of May it arrived in England. From Neill's history of the company we learn that the iron ore was smelted, and "seventeen tons of metal were sold at £4 per ton to the East India Company." This was undoubtedly the first iron made by Europeans from American ore. In 1610 Sir Thomas Gates, who had spent some time in Virginia, testified before the council of the company, at London, that there were divers minerals, especially "iron oare," in Virginia, lying upon the surface of the ground, some of which ore, having been sent home, had been found to yield as good iron as any in Europe. The iron here referred to was that which had been sold to the East India Company.

In 1619 the Virginia Company sent to Virginia a number of persons who were skilled in the manufacture of iron, to

"set up three iron works" in the colony. The enterprise was undertaken in that year, and was located on Falling creek, a tributary of the James river, which it enters on its right or southern bank in Chesterfield county, about seven miles below Richmond, and about sixty-six miles above Jamestown. In 1620, as stated by Beverley in his *History of Virginia*, "an iron work at Falling creek, in James river," was set up, "where they made proof of good iron oar, and brought the whole work so near a perfection that they writ word to the company in London that they did not doubt but to finish the work and have plentiful provision of iron for them by the next Easter"—in the spring of 1621. But neither "plentiful provision" nor any other provision of iron was made on Falling creek in 1621, owing to the death of three of the master workmen who had the enterprise in charge. In July of that year the company sent over Mr. John Berkley, "formerly of Beverstone Castle, Gloucester, a gentleman of an honorable family," to take charge of the work. He was accompanied by his son Maurice and twenty experienced workmen. In a letter from the company to the colonial authorities, dated July 25, 1621, it was stated that "the advancement of the iron works we esteeme to be most necessarie, by perfecting whereof we esteeme the plantation is gainer. We therefore require all possible assistance be given to Mr. Berkley now sent, and all furtherance to his ship, especially good entertainment at their landinge." On the 12th of August of the same year the company, in a communication to the authorities, wrote respecting the iron works and the saw mills which had been projected: "We pray your assistance in the perfectinge of these two workes; the profitt will redound to the whole collony, and therefore it is necessary that you extend your authoritie to the utmost lymitts to enforce such as shall refuse the help to a business so much tending to the generall good." On the 5th of December, 1621, the company again wrote, enjoining "all possible dilligence and industrious care, to further and accomplish those great and many designes of salte, sawinge mills, and iron." In January, 1622, the authorities wrote to the company that "the care we have taken of the iron workes we reserve to be reported by Mr. Thresurer and Mr. Barkley himself." On June 10th the company wrote of "the good en-

terance w^{ch} we have understood you have made in the iron works, and other staple comodities," and added, "let us have at least by the next returnes some good quantitie of iron and wyne." But before this letter was written the colony had been visited by the Indian massacre of the 22d of March, 1622, in which John Berkley and all his workmen were slain and the iron works were destroyed. These works were not rebuilt. Beverley, writing in 1705, says the project of iron works on Falling creek "has never been set on foot since, till of late; but it has not had its full trial." In 1624 the charter of the Virginia Company was revoked. And thus ended disastrously the first attempt by Europeans to make iron in America.

The "good enterance" mentioned in the company's letter of June 10th doubtless referred to satisfactory progress in the construction of the works, but there is no positive evidence that iron was ever made on Falling creek. Letters from Mr. John Berkley had promised that "the company might relye upon good quantities of iron made by him" by Whitsuntide of 1622, but the massacre occurred before that time. Beverley, however, in referring to the Falling creek enterprise, says that "the iron proved reasonably good; but before they got into the body of the mine the people were cut off in that fatal massacre." The ore on Falling creek is described as having been brown in color. Mr. Berkley declared that "a more fit place for iron workes than in Virginia, both for woods, water, mynes, and stone," was not to be found; and Mr. George Sandys wrote to the company on the 3d of March, 1622, that Falling creek was fitted for making iron "as if Nature had applyed herselfe to the wish and dictation of the workeman; where also were great stones, hardly seene elsewhere in Virginia, lying on the place, as though they had beene brought thither to advance the erection of those workes."

We have failed to discover whether the works on Falling creek embraced a blast furnace and refinery or a bloomary only, but the frequent references to building stone in connection with the works, and the length of time and the number of workmen occupied in their erection, lead to the inference that a furnace formed part of the enterprise. It also seems reasonable to suppose that the phrase, "three iron works," already quoted in connection with the plans of the Virginia

Company, meant a furnace, a "finery," and a "chafery," these three works being used together in England at that day.

No further attempt to make iron in Virginia appears to have been made for many years after the failure on Falling creek. In a pamphlet entitled *A Perfect Description of Virginia*, published at London in 1649, it is stated that "an iron work erected would be as much as a silver mine." In 1650 another pamphlet, quoted by Bishop, says of iron ore in Virginia: "Neither does Virginia yield to any other province whatsoever in excellency and plenty of this oare." In 1687, and again in 1696, Col. William Byrd, the first of the name in Virginia, set on foot the project of reviving the works on Falling creek, but it was not carried into execution. This is the project referred to by Beverley in 1705 as not having had "its full trial."

To encourage manufactures in Virginia the exportation from the colony of hides, wool, and iron was forbidden by an act of the assembly in 1662, upon penalty of one thousand pounds of tobacco for every hide exported, fifty pounds of tobacco for every pound of wool exported, and ten pounds of tobacco for every pound of iron exported. The restriction was removed in 1671, "no successe answering the conceived hopes and apparent losses accruing to all inhabitants by the refusall of those concerned to buy the commodityes aforesaid," but it was re-enacted in 1682. We can not learn that during all the time covered by these enactments, and down to the beginning of the eighteenth century, there was a single pound of iron manufactured in Virginia. Notwithstanding the wise encouragement given by the Virginia Company and by some succeeding colonial authorities to the establishment of manufactures, the Virginia settlers for a hundred years after the settlement at Jamestown devoted themselves almost entirely to the raising of tobacco and other agricultural products.

R. A. Brock, Esq., of Richmond, a gentleman who has devoted much time to historical researches concerning Virginia, and who is at present corresponding secretary and librarian of the Virginia Historical Society, has recently published an account of some of the iron enterprises in the colony in the eighteenth century, from which the following interesting reference to the site of the iron works on Falling creek is taken.

The Falling creek tract fell to the possession of Col. Archibald Cary some time prior to the Revolutionary war. Upon it he erected his well-known seat, the name of which became in the records of the period a part and parcel of his personal designation as Archibald Cary of Ampthill. He erected new iron works on Falling creek. "He purchased pigs of iron from Rappahannock, Patowmack, and Maryland. Of these he made bar iron. The profits, however, were so small that he abandoned his forge and converted his pond to the use of a grist mill about 1760. Nobody then knew of any iron mine convenient to Falling creek."

Falling creek is about a mile below Ampthill. Its waters still furnish motive power to a grist mill owned by Mr. H. Carrington Watkins, and known as the Ampthill mill. The creek is but an insignificant rivulet above the mill, but some twenty yards below it widens into a handsome little lake, and some quarter of a mile thence empties into James river.

About sixty yards from the mill, on the western bank of the creek and nearing the river, the writer picked up several small pieces of furnace cinder, presumptive relics of the iron works of 1622. The bluff adjacent and incumbent has, it is evident, from repeated washings of the soil, nearly covered the exact original site.

On the opposite side of the creek, and to the east of the mill, is clearly indicated the site of the forge of Archibald Cary. Here we found numerous pieces of slag or cinder, some of them fully a hundred pounds in weight, and an irregular area, an acre or more in extent, covered with finely-broken or comminuted charcoal to the depth of fully two feet; a memorial of the fuel used.

We were informed that about half a mile below Falling creek, near James river, there is a low piece of ground known to this day as Iron Bottom, where may be found plentifully what is known as bog iron on the surface. It will be recollected that the iron ore already cited as being mentioned by Sir Thomas Gates was described as "lying on the surface of the ground." We have also learned since our visit to Falling creek that at a point upon its banks, distant inward about two miles from the site of the iron works, there are numerous pits some five or six feet in depth, which it is evident, from the mineral character of their surroundings, furnished the crude ore for the original and ill-starred works.

In the eighteenth century Virginia became very prominent in the manufacture of iron, fulfilling in an eminent degree, although at a late day, the expectations which had been entertained of its iron-producing capabilities by the enterprising but ill-fated Virginia Company of London.

CHAPTER VII.

BEGINNING OF THE MANUFACTURE OF IRON IN THE NEW ENGLAND COLONIES.

ALTHOUGH iron ore in this country was first discovered in North Carolina, and the manufacture of iron was first undertaken in Virginia, the first successful iron works were established in the province of Massachusetts Bay. In 1632 mention is made by Morton of the existence of "iron stone" in New England, and in November, 1637, the general court of Massachusetts granted to Abraham Shaw one-half of the benefit of any "coles or yron stone w^ch^ shal be found in any comon ground w^ch^ is in the countryes disposeing." Iron ore had also been found in small lakes or ponds on the western bank of the Saugus river, near Lynn, soon after its settlement in 1629, and in 1642 specimens of it were taken to London by Robert Bridges, in the hope that a company might be formed for the manufacture of iron. This hope was realized in the formation of "The Company of Undertakers for the Iron Works," consisting of eleven English gentlemen, who advanced £1000 to establish the works. John Winthrop, Jr., had previously gone to England, and he appears to have assisted Mr. Bridges in securing the organization of the company. He became a member of the company, as did others among the colonists. Thomas Dexter and Robert Bridges, both of Lynn, were among the original promoters of the enterprise. Lewis, in his *History of Lynn*, published in 1844, says that in 1643 "Mr. John Winthrop, Jr., came from England with workmen and stock to the amount of one thousand pounds, for commencing the work. A foundry was erected on the western bank of Saugus river. . . The village at the foundry was called Hammersmith by some of the principal workmen who came from a place of that name in England." In Newhall's revision of Lewis's history, published in 1865, the iron works are said to have been located near the site of the present woolen factories in Saugus Centre, a suburb of Lynn, where large heaps of scoria are still to be seen. "This iron foundry at

Lynn," says Lewis, "was the first which was established in America." Lynn is about ten miles northeast of Boston.

In 1644, and subsequently, as stated by Lewis, the general court granted many special privileges to the company. On March 7, 1644, it was granted three miles square of land at each of six places it might occupy in the prosecution of its business. On November 13, 1644, it was allowed three years "for y^e perfecting of their worke and furnishing of y^e country with all sorts of barr iron." The citizens were granted liberty to take stock in the enterprise "if they would complete the finery and forge, as well as the furnace, which is already set up." On the 14th of May, 1645, the general court passed an order declaring that "y^e iron worke is very successful (both in y^e richness of y^e ore and y^e goodness of y^e iron)," and that between £1,200 and £1,500 had already been disbursed, "with which y^e furnace is built, with that which belongeth to it, . . and some tuns of sowe iron cast . . in readines for y^e forge. . . There will be neede of some £1,500 to finish y^e forge." On the 14th of October of the same year the company was granted still further privileges by the general court, on the condition "that the inhabitants of this jurisdiction be furnished with barr iron of all sorts for their use, not exceeding twentye pounds per tunn," and that the grants of land already made should be used "for the building and seting up of six forges, or furnaces, and not bloomaries onely." The grant was confirmed to the company of the free use of all materials "for making or moulding any manner of gunnes, potts, and all other cast-iron ware." On the 6th of May, 1646, Richard Leader, the general agent of the company, who is described as a man of superior ability, purchased "some of the country's gunnes to melt over at the foundery." On August 4, 1648, Governor Winthrop wrote from Boston to his son, who had removed to Pequod, Connecticut, that "the iron work goeth on with more hope. It yields now about 7 tons per week." On September 30th he writes again: "The furnace runs 8 tons per week, and their bar iron is as good as Spanish." Newhall quotes from a Lynn account book for 1651 the following entry: "James Leonnarde, 15 days worke about finnerey chimneye and other worke in y^e forge, 1: 13: 0. To ditto Leonard for dressing his bellows 3 times, 1: 10: 0." Edward Johnson,

of Woburn, in describing Lynn in 1651, in his *Wonder Working Providence*, printed in that year, says: "There is also an iron mill in constant use;" and Mr. Lewis states that, prior to 1671, "the iron works for several years were carried on with vigor, and furnished most of the iron used in the colony." After 1671 they passed under a cloud, and about 1688 they appear to have finally ceased operations. Their owners were harassed after 1651 with frequent lawsuits, arising from the overflow of the water in the dam. The fear that the works would create a scarcity of timber also appears to have added to their unpopularity. Hubbard, writing about 1677, says that "a work was set up at Lynn upon a very commodious stream, which was very much promoted and strenuously carried on for some time, but at length, instead of drawing out bars of iron for the country's use, there was hammered out nothing but contentions and lawsuits."

From the foregoing details it is plainly established that the enterprise at Lynn embraced a blast furnace, or "foundery," and a refinery forge. The term "foundery" was long a synonym for "furnace," castings being made directly from the furnace, as has been previously stated. This practice continued in this country down to almost the middle of the present century, and it is still followed in many European countries. That the furnace was in operation in May, 1645, is certain, and that the forge was in operation in September, 1648, is equally certain. These dates may be accepted as definitely determining, respectively, the first successful attempts in this country to make "sowe iron" and other castings in a blast furnace and to make "barr iron" in a refinery forge from "sowe iron."

Joseph Jenks was a machinist at the Lynn iron works, who had come from Hammersmith in England, and was a man of much skill and inventive genius. He prepared the moulds for the first castings that were made at Lynn. "A small iron pot, capable of containing about one quart," was the first article cast at the furnace. In 1844 it was in the possession of Mr. Lewis's mother, who was a lineal descendant of Thomas Hudson, the first owner of the lands on Saugus river on which the iron works were built, and who obtained possession of the pot immediately after it was cast, "which he preserved as a

curiosity." "It has been handed down in the family ever since," wrote Mr. Lewis in 1844.

Joseph Jenks, who became the founder of an eminent New England family, purchased from Richard Leader on the 20th of January, 1647, the privilege of building a forge at the Lynn iron works for the manufacture of scythes and other edge tools. This enterprise was successful. In 1652 he made at the Lynn iron works, for the mint which was that year established at Boston, the dies for the first silver pieces coined in New England. On one side of these coins was the impression of a pine tree. In 1654 he made for the city of Boston the first fire engine made in America. In 1655 the general court granted him a patent for an improved scythe. His name is also associated with other inventions. He died in 1683.

Henry and James Leonard were also skilled workmen at the Lynn iron works. They and their descendants were afterwards connected with other colonial enterprises. They had a brother Philip, who does not appear to have lived at Lynn. Rev. Dr. Fobes, in referring to the Leonard family in his *Topographical Description of the Town of Raynham*, written in 1793, says that "the circumstance of a family attachment to the iron manufacture is so well known as to render it a common observation in this part of the country, 'Where you can find iron works there you will find a Leonard.'" Henry and James Leonard are said to have learned their trade at Pontypool in Monmouthshire.

The second iron enterprise that was undertaken in New England embraced a furnace and forge at Braintree, about ten miles south of Boston. The works at Lynn and Braintree belonged to the same company. Bishop says that, on the 19th of November, 1643, a grant of 3,000 acres of the common land at Braintree was made to Mr. Winthrop and his partners, the Lynn company, "for the encouragement of an iron work to be set up about Monotcot river." But this grant, according to Lewis, was not surveyed until January 11, 1648. On the 29th of September, 1645, as stated by Lewis, the first purchase of land, consisting of twenty acres, "for a forge at Braintree," was made from George Ruggles by Richard Leader, who was the general agent for the company of undertakers. The furnace was probably built in 1646. Robert Child, writing from Bos-

ton on the 15th of March, 1647, to John Winthrop, Jr., "at Pequot river," says of the Lynn and Braintree enterprises: "We have cast this winter some tuns of pots, likewise mortars, stoves, skillets. Our potter is moulding more at Brayntree as yet, which place after another blowing we shall quit, not finding mine there." We find, however, that iron ore was mined at Braintree in the early part of 1652, and that, on the 28th of September of that year, it was proposed at London, on behalf of the undertakers, to employ William Osborne at "Brantry furnas & fordges." Lewis states that in 1691 "iron ore, called 'rock mine,' was taken from the ledges at Nahant for the forge at Braintree." Henry Leonard is supposed to have superintended the erection of the Braintree works. John Gifford was the manager of the works, according to Newhall, and in 1651 he succeeded Richard Leader as agent for the works at Lynn.

The next iron enterprise in New England was located in the town, or township, of Taunton, now Raynham, two miles from the city of Taunton, in Bristol county. This enterprise was undertaken in 1652 by Henry and James Leonard and Ralph Russell. At a town meeting at Taunton, held October 21, 1652, "it was agreed and granted by the town to the said Henry Leonard and James Leonard, his brother, and Ralph Russell, free consent to come hither and join with certain of our inhabitants to set up a bloomery work on the Two-mile river." The Taunton works, sometimes called the Raynham works, are referred to by Lewis as "Leonards' celebrated iron works." They were well managed, and long continued in a prosperous condition. At these works bar iron was made directly from the ore. As Henry Leonard was at Lynn in 1655, and as James Leonard does not appear to have been there after 1652, it is probable that the latter and his sons became the sole owners of the Raynham works. Dr. Fobes gives an account of the intimacy which existed between the Leonards at Raynham and King Philip, through which they were protected against Indian outrages. Sanford, in his *History of Raynham*, says: "Philip had a summer hunting-seat near the Fowling pond. The Leonards had supplied him with beef, repaired his muskets, and furnished him with such simple tools as the Indians could use." Philip's head, says Fobes,

was deposited in the cellar of James Leonard's house for a considerable time after his death in 1676. At the date of Dr. Fobes's book, 1793, this house was occupied by Leonards of the sixth generation. The forge, says this writer, was situated on "the great road, and, having been repaired from generation to generation, it is to this day still in employ." In William Read Deane's *Genealogical Record of the Leonard Family*, published in 1851, it is stated that "the old forge, though it has been several times remodeled, has been in constant use for nearly two hundred years, and is now in the full tide of successful operation. It is owned by Theodore Dean, Esq., who is descended from the Leonards." The forge was at that time employed in the manufacture of anchors. In 1865 it was still so employed, with six forge fires, two hammers, and four water-wheels, but about that time it ceased to be active and has not since been in operation. The works are now in a dilapidated condition. Theodore Dean was recently the owner. *This forge is the oldest iron establishment in the country that is now in existence.* Fowling pond, which was originally nearly two miles long and three-quarters of a mile wide, was close to the forge, and supplied it with ore. A blast furnace, for the manufacture of hollow-ware, was built on a branch of Two-mile river before the Revolution, but it has long been abandoned.

In Ricketson's *History of New Bedford* it is stated that "one of the earliest settlers of Dartmouth was Ralph Russell, who came from Pontypool, in England, and had been engaged in the iron business with Henry and James Leonard, of Taunton. He set up an iron forge at 'Russell's Mills,' which place received its name from him."

In 1657 the general court of Massachusetts, owing to the failure of the undertakers at Lynn and Braintree to furnish the colony with a constant supply of iron, "whereby unsufferable damage may accrew," granted to the inhabitants of Concord and Lancaster, and such as they should associate with them, "liberty to erect one or more iron workes within the limitts of theire oune toune bounds, or in any common place neere thereunto." That this grant resulted in the establishment of an iron work at Concord, which place has since become famous through its association with the outbreak of hostilities between the mother country and the colonies in 1775,

appears probable from the grant by the court in 1660, to "ye company in partnership in the iron worke at Concord," of "free liberty to digg mine without molestation in any lands now in the court's possession."

About 1668 Henry Leonard went to Rowley Village, about 25 miles northeast of Lynn, as stated by Newhall, "and there established iron works." Lewis says that in 1674 Henry Leonard's sons, Nathaniel, Samuel, and Thomas, contracted to carry on these works for the owners, whose names are given by Bishop as "John Ruck and others of Salem." The works did not prove to be profitable. After establishing the Rowley works Henry Leonard went to New Jersey, "and there again engaged in the iron manufacture." At some time previous to his removal to New Jersey he appears to have been connected with the establishment of iron works at Canton, about fourteen miles south of Boston.

Other iron enterprises in Massachusetts speedily followed in the same century those that have been mentioned. In 1677 one of these works, the name of which has not come down to us, was destroyed by the Indians. About the same year iron was made at Topsfield, near Ipswich, and in 1680 its manufacture was commenced at Boxford. Hubbard, writing about 1677, says that at that time there were in the colonies "many convenient places, where very good iron, not much inferior to that of Bilbao, may be produced, as at this day is seen in a village near Topsfield, seven or eight miles west from Ipswich." About 1696 George Leonard is said to have erected "an iron-working establishment" at Norton, about 27 miles southwest of Boston.

For a hundred years after its settlement in 1620 Massachusetts was the chief seat of the iron manufacture on this continent. Most of its iron enterprises during this hundred years were bloomaries, but there were blast furnaces also, although the latter as a rule produced only hollow-ware and other castings, and not pig iron. During the period mentioned the iron industry of Massachusetts was confined to the eastern counties of the colony, where bog and pond ores formed probably the only kinds of ore that were obtainable.

The English settlement at New Haven closely followed Massachusetts in the manufacture of iron. John Winthrop,

Jr., who removed from Lynn to Pequod, (New London,) Connecticut, in 1645, had obtained from the general court in the preceding year permissión to set up an iron work, and in 1651 he obtained a grant of certain privileges to enable him to "adventure" in the manufacture of iron; but he does not seem to have embarked in the iron business until subsequently. On the 30th of May, 1655, according to Bishop, it was ordered by the assembly of New Haven "that if an iron worke goe on within any part of this jurisdiction the persons and estates constantly and onely imployed in that worke shall be free from paying rates." In 1658 Captain Thomas Clarke, in connection with John Winthrop and others, put in operation an "iron worke" at New Haven, and in 1669 he seems to have been still engaged in the same enterprise, for in that year the general court of Connecticut continued the exemption already noted for another seven years, "for encouragement of the said worke in supplying the country with good iron and well wrought according to art." This enterprise embraced a blast furnace and refinery forge. On the 22d of June, 1663, John Davenporte wrote from New Haven to John Winthrop, Jr., as follows: "The freshest newes here, & that which is *e re vestra*, is, that they have bene blowing at the iron worke, and have runne, from the last 6th day to this 2d day, 5 sowes of iron, which are commended for very good; & this night it's thought they will run another, & begin to-morrow to make pots. The worke is hopeful, but the workemen are thought to be very chargeable and froward." This frowardness was due apparently to the influence of an old enemy of iron works and ironworkers, John Barleycorn. Bishop records "a proposition made in May, 1662, 'in y^e behalfe of Capt. Clarke, that wine and liquors drawn at the iron workes might be custome free,' which was allowed to the extent of one butt of wine and one barrell of liquors, and no more."

Rhode Island made iron soon after its settlement in 1636 —certainly at Pawtucket and elsewhere as early as 1675, when the forge at Pawtucket, erected by Joseph Jenks, Jr., son of Joseph Jenks, the machinist at Lynn, was destroyed by the Indians in the Wampanoag war, together with other iron works and infant enterprises. A third Joseph Jenks was Governor of Rhode Island from 1727 to 1732. The few forges and furnaces

that were erected in this colony in the seventeenth century used bog or pond ore, but in the succeeding century rock ore, found in the township of Cumberland, was also used. There is a valuable deposit of magnetic iron ore in this township, known as Cumberland hill, which has recently attracted attention because of its supposed adaptability to the manufacture of steel. This hill, or mountain, is described as forming "a homogeneous mass of iron ore, about 500 feet long by 150 feet wide and 104 feet high, or, in bulk, equal to about 1,000,000 tons above water level, while, as the deposit shows an indefinite extension in depth, the quantity of this ore may be said to be practically inexhaustible."

Iron does not appear to have been made within the limits of Maine, New Hampshire, or Vermont until the eighteenth century.

CHAPTER VIII.

EXTENSION OF THE MANUFACTURE OF IRON IN NEW ENGLAND.

Doctor James Thacher, in his valuable essay on the iron ores and iron enterprises of Plymouth county, Massachusetts, printed in 1804, says: "The first furnace for smelting iron ore, known in the county of Plymouth, was erected in the year 1702 by Lambert Despard (a founder) and the family of Barkers, his associates, at the mouth of Mattakeeset pond in the town of Pembroke, but the wood in the vicinity being exhausted the works were long since abandoned." In James Torrey's *History of Scituate*, in Plymouth county, written in 1815, mention is made of an iron enterprise in the township of Scituate, as follows: "In 1648 Mr. Timothy Hatherly, the principal founder and father of the town of Scituate, requested liberty of the colony to erect an iron mill. It was granted in 1650, conditional to be erected within three years, or the privilege, certain woodlands about Mattakeeset pond, (now Pembroke,) to revert to the colony. It did not, however, take place at that period, but 'a smelting furnace was erected on the precise grant by Mark Despard and the family of Barker, about 1702.'" With the building of this furnace the iron history of Massachusetts in the eighteenth century may be said to begin.

The enterprise of Despard and the Barkers was speedily followed by the erection of a bloomary forge on Bound brook, near Hingham, in 1703, by a company in which two brothers, Daniel and Mordecai Lincoln, were partners. Mordecai Lincoln is supposed to have been an ancestor of Abraham Lincoln. In Torrey's *History of Scituate* mention is made of the erection of the Drinkwater iron works, near Abington, about 1710, by a person named Mighill, probably Rev. Thomas Mighill. The first slitting mill in the colonies, for slitting nail rods, is said by tradition to have been erected at Milton, in Norfolk county, as early as 1710; but Bishop accords this honor to Middleborough, in Plymouth county, at a later day.

About 1722 a bloomary forge was built at Bridgewater, which was active in 1750. In 1738 Hugh Orr, a Scotchman, established at this place a gun factory, and about 1748 he made five hundred muskets for the province of Massachusetts Bay, which are believed to have been the first muskets manufactured in this country. Subsequently he established a cast-iron cannon foundry at Bridgewater, and was instrumental in promoting various other manufacturing enterprises. In 1730 iron works were erected at Plympton, now Carver, which appear to have embraced a blast furnace, as mention is made of iron tea-kettles having been cast at Plympton between 1760 and 1765. In 1731 there were officially reported to be in Massachusetts "several forges for making bar iron, and some furnaces for cast iron or hollow-ware, and one slitting mill, and a manufacture for nails." At the same time there were in all New England "six furnaces, meaning hollow-ware furnaces, and nineteen forges, meaning bloomaries, not refineries." "At that time," says Douglass, in his *British Settlements*, "we had no pig furnaces nor refineries of pigs" in New England. Refineries were in use about twenty years later. In 1750 there were four slitting mills in Massachusetts—two at Middleborough, one at Hanover, and one at Milton; also a plating-forge with a tilt-hammer, and one steel furnace. In 1750 Douglass thus described the iron industry of New England:

Iron is a considerable article in our manufacture; it consists of these general branches: (1) Smelting furnaces reducing the ore into pigs; having coal enough and appearances of rock ore. In Attleborough were erected at a great charge three furnaces, but the ore proving bad and scarce this projection miscarried as to pigs. They were of use in casting of small cannon for ships of letters of marque, and in casting cannon-balls and bombs toward the reduction of Louisbourg. (2) Refineries which manufacture pigs, imported from New York, Pennsylvania, and Maryland furnaces, into bar iron. (3) Bloomaries, which, from bog or swamp ore, without any furnace, only by a forge hearth, reduce it into a bloom or semi-liquidated lump to be beat into bars, but much inferior to those from the pigs or refineries. (4) Swamp ore furnaces; from that ore smelted they cast hollow-ware which we can afford cheaper than from England or Holland.

Bog or swamp ore lies from half a foot to two feet deep. In about 20 years from digging it grows or gathers fit for another digging; if it lies longer it turns rusty and does not yield well. Three tons of swamp ore yield about one ton of hollow-ware.

One hundred and twenty bushels of charcoal are sufficient to smelt rock ore into one ton of pigs. The complement of men for a furnace is

eight or nine, besides cutters of wood, coalers, carters, and other common laborers.

In New England we have two slitting mills for nail rods: one in Milton, eight miles from Boston, and another in Middleborough, about thirty miles from Boston, which are more than we have occasion for. Our nailors can afford spikes and large nails cheaper than from England, but small nails not so cheap.

In New England they do not forge bar iron sufficient for their home consumption by bloomaries and refineries; they import from England, New York, Jersies, Pennsylvania, and Maryland.

The development of the rich iron ores of the Berkshire hills, in Western Massachusetts, commenced about 1750. A furnace was built at Lenox, in Berkshire county, in 1765, and it made pig iron in the following year. It had an exceptionally high stack for that day—28 feet high, and was blown with one tuyere. This furnace was torn down in 1881. Previous to 1773 a furnace was built at Furnace Village, in Worcester county, and a few years after that date there were several bloomaries and one refinery forge in the same county. In 1793 the county contained several manufactories of edge tools, hardware, machinery, etc. In the township of Sutton there were at this time one axe, one hoe, and five scythe manufactories, and several naileries. In the whole county there were seventeen trip-hammers. At Springfield, in Hampden county, as stated by Bishop, some cannon were cast and some forging was done during the Revolutionary war, but small arms were not made until after the peace. The Government armory at Springfield was established in 1794.

While the iron manufacture of Massachusetts was thus being extended westward it continued to make rapid progress in the eastern counties. Charlotte furnace at Middleborough was built in 1758, and was in operation for many years. During our two wars with the mother country it was employed in casting shot and shells. The shot which the *Constitution* carried in her conflict with the *Guerrière* were cast at this furnace. In 1784 there were seventy-six iron works in Massachusetts, "many of them small." At Amesbury, in Essex county, a furnace was erected about 1790, and at Boxborough, in Middlesex county, a bloomary forge was built about the same time. In 1795 Dr. Morse reported eleven slitting mills in Bristol, Norfolk, and Plymouth counties, which rolled and

cut in that year 1,732 tons of iron into hoops and nail rods. Bishop says that "the two counties of Plymouth and Bristol had in operation in 1798 fourteen blast and six air furnaces, twenty forges, and seven rolling and slitting mills, in addition to a number of trip-hammers and a great number of nail and smith shops. Cut and hammered nails, spades and shovels, card teeth, saws, scythes, metal buttons, cannon balls, bells, fire arms, sheet iron for tin ware, wire, etc., were made in large quantities." Steel was made from crude iron at Canton about 1797, "by the German process." In 1804 there were ten blast furnaces in Plymouth county, all producing castings exclusively. In 1830 only three of these were left—Charlotte, Federal, and Pope's Point, all in Carver township, and all in operation. There were also in 1804 ten forges in the same county, which were principally employed in working "old iron scraps," broken pots, kettles, etc., and produced in all about 200 tons of bar iron per annum.

Dr. James Thacher, who was a part owner of Federal furnace, wrote in 1804 a description of this furnace, which was built in 1794, and is said by him to have been the most valuable furnace with which he was acquainted, the manufacture of castings being "there prosecuted to great extent and advantage." The furnace was built of stone, as were all other Plymouth furnaces. It was 20 feet high and 24 feet square, its walls being 7 feet thick and its interior 10 feet in diameter. Charcoal was the only fuel used, and marine shells formed the only fluxing material. The furnace was lined with "fire stone" composed of "soft slate." A brick funnel at the top of the stack served "to convey off the blaze and smoke." The Doctor continues his description as follows:

At the bottom of an arch in the front of the furnace is an aperture, from which the workmen remove the scoria and dip out the metal. And in another arch on one side there is a small aperture for the insertion of the pipes of two large bellows 22 feet long and 4 feet wide, which being kept in constant alternate motion by the agency of a water-wheel 25 feet diameter, a powerful current of air is excited; and being impelled upon the surface of the fuel the fusion of the metal is greatly accelerated. The whole of this machinery is included in a large wooden building, affording accommodation to the workmen with their apparatus for moulding and casting.

The specific articles manufactured at the Federal furnace are, besides hollow-ware of every description, Seymour's patent rolls for slitting mills, of a superior quality, cast in iron cylinders, potash kettles, stoves, fire-backs

and jambs, plates, gudgeons, anvils, large hammers, cannon shot of every kind, with a vast variety of machinery for mills, etc.

The ores used in the furnaces and bloomaries of Eastern Massachusetts were chiefly bog and pond ores. Dr. Thacher says, however, that in 1804 "a very considerable proportion of ore smelted in our furnaces is procured from the very productive mines at Egg Harbor, in the State of New Jersey, of a reddish brown color, producing from 30 to 40 per cent. of excellent iron. The usual price is $6.50 per ton." He also says that "reddish brown" ore in large lumps was obtained from a mine on Martha's Vineyard, "affording about 25 per cent. and worth $6 per ton." The pond ores contained from 20 to 30 per cent. of iron, and the average price was about $6 per ton at the furnace. Bog ore, found in swamps and other low places, was of a "rusty brown color, yielding about 18 per cent. and worth $4 per ton at the furnace." The following letter from the Rev. Isaac Backus, of Middleborough, dated July 25, 1794, gives a description of the manner in which pond ores were obtained.

Vast quantities of iron, both cast and wrought, have been made in this part of the country for more than a hundred years past; but it was chiefly out of bog ore, until that kind was much exhausted in these parts, and then a rich treasure was opened in Middleborough, which had been long hid from the inhabitants. About the year 1747 it was discovered that there was iron mine in the bottom of our great pond at Assowamset; and after some years it became the main ore that was used in the town, both at furnaces and forges, and much of it has been carried into the neighboring places for the same purpose. Men go out with boats, and make use of instruments much like those with which oysters are taken, to get up the ore from the bottom of the pond. I am told that, for a number of years, a man would take up and bring to shore two tons of it in a day; but now it is so much exhausted that half a ton is reckoned a good day's work for one man. But in an adjacent pond is now plenty, where the water is twenty feet deep, and much is taken up from that depth, as well as from shoaler water. It has also been plenty in a pond in the town of Carver, where they have a furnace upon the stream which runs from it. Much of the iron which is made from this ore is better than they could make out of bog ore, and some of it is as good as almost any refined iron. The quantity of this treasure, which hath been taken out of the bottom of clear ponds, is said to have been sometimes as much as five hundred tons in a year.

In 1721 Samuel Bissell, of Newport, in Rhode Island, a blacksmith, received a loan of two hundred pounds from the colonial treasury to enable him to carry on the manufacture

of nails. In 1735 Samuel Waldo erected a furnace and foundry on the Pawtuxet river, in Rhode Island, which were afterwards known as Hope furnace. These are said to have been the most important iron works in the State during the eighteenth century. Cannon and other castings were made here. During the Revolution they were active in producing cannon, cannon balls, and other munitions of war. About the year 1735 three other furnaces were erected, in Cumberland township, in the northeastern part of the State, but they seem to have been abandoned before the Revolution. They made "cannon, bombs, and bullets" during the French war of 1755. In 1741 James Greene and others erected works on the south branch of the Pawtuxet river, in the town of Warwick, "for the refining of iron." In 1765 a furnace was built on the north branch of the same river by Stephen Hopkins and others. In 1789 a rolling and slitting mill were established near Providence, on one of the branches of Providence river, and before 1800 a rolling and slitting mill had been established at Pawtucket Falls, and other iron-manufacturing enterprises in various parts of the State. Bishop says that "manufactures of iron, including bar and sheet iron, steel, nail rods and nails, farming implements, stoves, pots, and other castings and household utensils, iron works for shipbuilders, anchors, and bells formed the largest branch of productive industry in the State toward the close of the eighteenth century."

Litchfield county, in Northwestern Connecticut, contains iron-ore mines of great value, from which the ore for the celebrated "Salisbury iron" has been taken for a hundred and fifty years. This ore is of a quality similar to that found in Berkshire county, Massachusetts, already referred to. As early as 1734 a bloomary forge was erected at Lime Rock, in Litchfield county, by Thomas Lamb, which produced from 500 to 700 pounds of iron per day. A blast furnace was afterwards added to this forge, and it is still active. About 1748 a forge was erected at the village of Lakeville, in the same county, and in 1762 John Haseltine, Samuel Forbes, and Ethan Allen purchased the property and built a blast furnace, but soon afterwards sold it to Charles and George Caldwell, of Hartford. It made two and a half tons of iron in twenty-four

hours, and three tons of ore and 250 bushels of charcoal were used per ton of iron. Its blowing apparatus consisted of a pair of leather bellows driven by a water-wheel. In 1768 the furnace was sold to Richard Smith, of Hartford. Smith was a royalist, and fled to England during the Revolution, but his furnace was made to produce large quantities of cannon, cannon balls, shells, etc., for the Continental army. After the Revolution it made cannon for the navy, potash kettles weighing nearly half a ton each, and pig iron for forges and foundries. Many bloomary forges were established in this county about the close of the last century. One of these was built on Mount Riga, five miles north of Lakeville, about 1781, by Abner or Peter Woodin. It was afterwards owned by Daniel Ball, and was called Ball's forge. About 1806 Seth King and John Kelsey commenced to build a furnace on Mount Riga, but they were not able to finish it, and in 1810 it fell into the hands of Holley & Coffing, who completed it in that year and operated it for many years. About thirty furnaces have been built and operated within a radius of thirty miles of Lakeville, a few of which were in New York and Massachusetts, but the majority were in Connecticut. At the close of the eighteenth century Litchfield county contained fifty bloomary forges, which made iron directly from the ore, and three slitting mills. At the same time the county was so prominent in the manufacture of nails that only Plymouth and Bristol counties in Massachusetts, of all the nail-making districts in the country, exceeded its production. The iron of Litchfield county is now used entirely for foundry purposes, and most of it is used in the manufacture of car wheels.

Bishop says that Oldmixon, in his *British Empire in America*, mentions "a small iron mill" at Branford, in New Haven county, in 1741, on a small stream running into Long Island sound, and he adds that on many of the small streams and branches of the rivers which fall into the sound "bloomaries and small works for a variety of manufactures in iron were established, some of them quite early." The bloomaries were in part supplied with bog ore, "dug near them," and in part with better ores obtained elsewhere. Bishop also says that in 1794 a slitting mill and other iron works had been erected in East Hartford, a forge at Glastonbury, and two furnaces at

Stafford "which made sufficient hollow and cast-iron wares for the whole State." Lesley says that there were at one time, about the beginning of the present century, three blast furnaces on a branch of the Willimantic river, in Northern Connecticut, near the Massachusetts line, a mile or two apart. Three forges near them converted their pig iron into bar iron. Hebron furnace was south of the above-mentioned furnaces, and Enfield forge stood a few miles east of Windsor Locks. All of these furnaces and forges were stopped about 1837, when Scotch pig iron began to come into the country as a substitute for foundry pig iron of domestic manufacture.

Connecticut was among the first of the colonies to make steel. In 1728 Samuel Higley, of Simsbury, and Joseph Dewey, of Hebron, in Hartford county, represented to the legislature that the first-named had, "with great pains and cost, found out and obtained a curious art, by which to convert, change, or transmute common iron into good steel, sufficient for any use, and was the very first that ever performed such an operation in America." The certificates of several smiths, who had made a trial of the steel and pronounced it good, were produced. He and Joseph Dewey were granted the exclusive right for ten years "of practicing the business or trade of steel-making." A "steel furnace" was owned by Aaron Eliot, of Killingworth, in Middlesex county, previous to 1750, and in 1761 the Rev. Jared Eliot, of the same place, father of the above-mentioned Aaron Eliot, and grandson of John Eliot, the apostle to the Indians, succeeded in producing in a common bloomary forge a bar of excellent iron, weighing 50 pounds, from 83 pounds of black magnetic sand, and in his son's furnace a portion of the bar was converted into good steel. For producing this iron he was awarded a gold medal in 1762 by the London Society of Arts. This medal is now in the possession of Charles G. Elliott, of Goshen, New York. It is inscribed: "To the Rev. Jared Eliot, M. A., of N. England. MDCCLXII. For producing malleable iron from the American black sand." The medal was sent to Mr. Eliot from London in 1764 "by Thos. Fisher, to the care of our friend, Ben. Franklin." This sand, which is found in the southern parts of Connecticut, as well as in some other States, never received much further attention for conversion into iron or steel.

Iron ore was discovered near Portsmouth, in New Hampshire, as early as 1634, some of which was shipped to England, but we find no evidence that its discovery led to the establishment of any iron works in that century. The manufacture of iron in this State dates probably from about 1750, when several bog-ore bloomaries were in existence on Lamper Eel river, but were soon discontinued. About the time of the Revolution there were a few bloomaries in operation in New Hampshire. In 1791 mention is made of iron works at Exeter. At Furnace Village the magnetic iron ore of Winchester was first smelted in 1795 by a Rhode Island company. Franconia furnace, at Franconia, was built in 1811 by a company which was organized in 1805. This furnace was abandoned in 1865, and there is now no blast furnace in the State, nor any other enterprise for the manufacture of iron or steel except the extensive works of the Nashua Iron and Steel Company, at Nashua.

Maine had a few bloomary forges in York county during the Revolution and for some years afterwards, but she has had but few blast furnaces. A small furnace, capable of yielding a ton and a half of iron daily, was erected at Shapleigh, in York county, about 1838. It was used to produce castings, and cost only $13,000. A larger furnace, called Katahdin, was built in 1845 in Piscataquis county, and is still active. This is the only furnace now in the State. At an early period in its history it was operated for several years by the Hon. John L. Hayes, now of Cambridge, Massachusetts. A forge was erected near the furnace soon after 1845. In 1853 it made 700 tons of blooms. It was burned down about 1855. There were in 1884 two rolling mills in Maine, one at Portland and one at Pembroke.

The manufacture of iron was commenced in Vermont about 1775. Large deposits of iron ores similar to those of Western Massachusetts and Western Connecticut had previously been found in the southern and western parts of the State. In Rutland county ore was mined before 1785, and in 1794 there were fourteen forges, three furnaces, and a slitting mill in this county. In other counties there were seven forges in 1794—one in Bennington, four in Addison, and two in Chittenden. Before 1800 other forges and a slitting mill were added in this State; possibly a few furnaces. The township of Randolph,

in Orange county, had two forges and a slitting mill at this period. About the beginning of the present century there were twenty bloomaries in the neighborhood of Vergennes, in Addison county, all built with Boston capital. The prominence of Vermont in the manufacture of iron has now been lost, but it still contains one furnace and two bloomaries, and at St. Albans there is an establishment for the manufacture of steel.

The manufacture of nails was one of the household industries of New England during the eighteenth century. In a speech in Congress in 1789 Fisher Ames said: "It has become common for the country people in Massachusetts to erect small forges in their chimney corners; and in winter, and in evenings, when little other work can be done, great quantities of nails are made, even by children. These people take the rod iron of the merchant and return him the nails, and in consequence of this easy mode of barter the manufacture is prodigiously great." In a description of the town of Middleborough, in Plymouth county, Massachusetts, written in 1793 by Nehemiah Bennet, it is mentioned that "the most common and general employment of the inhabitants of said town is agriculture, which seems to be increasing; though there are a number of mechanicks. Nailing, or the business of making nails, is carried on largely in the winters, by the farmers and young men, who have but little other business at that season of the year." When Jacob Perkins, of Newburyport, Massachusetts, invented about 1790 his nail-cutting machine, which was patented in 1795 and speedily followed by other inventions for the same purpose, the occupation of making nails in the chimney corner met with a serious check. The manufacture of tacks by hand was also a New England household industry during the last century, and down to about fifty years ago. A writer in the *Furniture Trade Journal* thus describes this extinct industry: "In the queer-shaped, homely farmhouses, or the little contracted shops of certain New England villages, the industrious and frugal descendants of the Pilgrims toiled providently through the long winter months at beating into shape the little nails which play so useful a part in modern industry. A small anvil served to beat the wire or strip of iron into shape and point it; a vice, worked by the

foot, clutched it between jaws furnished with a gauge to regulate the length, leaving a certain portion projecting, which, when beaten flat by a hammer, formed the head. By this process a man might make, toilsomely, perhaps 2,000 tacks per day."

The earliest mention we have found of a machine for cutting nails occurs in Arnold's *History of the State of Rhode Island.* The author says: "It is said that the first cold cut nail in the world was made in 1777 by Jeremiah Wilkinson, of Cumberland, R. I., who died in 1832, at the advanced age of 90 years." Bishop gives a description of Wilkinson's very crude attempts to make cut nails and tacks. Speaking of Wilkinson's tacks he says: "They were first cut by a pair of shears (still preserved) from an old chest lock, and afterwards headed in a smith's vice. Sheet-iron was afterwards used and the process extended to small nails, which he appears to have been one of the first to attempt. They were cut from old Spanish hoops, and headed in a clamp or vice by hand. Pins and needles were made by the same person during the Revolution, from wire drawn by himself."

Nearly all the bloomary and refinery forges and old-style furnaces of New England have long disappeared, and in their stead have grown up reproductive iron industries of almost endless variety and vast extent, employing large numbers of skilled mechanics and adding greatly to the productive wealth of the country. The rolling mills, machine shops, hardware establishments, nail and tack factories, foundries, and other iron enterprises of New England, together with a few steel works and modern blast furnaces, (nearly all of the latter still using charcoal, however,) form to-day a striking contrast to the bog-ore and other bloomaries, not much larger than a blacksmith's fire, and the small charcoal furnaces and chimney-corner nail factories of the last century. "All that," says Lesley, "has given way and disappeared before the inventive spirit of New England, sustained and incited by the wealth of its commercial cities."

CHAPTER IX.

EARLY IRON ENTERPRISES IN NEW YORK.

DURING the rule of the Dutch in New York, from their first settlement on Manhattan Island in 1614 to their surrender to the English in 1664, iron ore was sought for and found in various places, but no effort to manufacture iron is known to have been made. Nor does it appear that the English established any iron works in the province until some time after the beginning of the succeeding century. A Parliamentary report, quoted by Pitkin, states that there were no iron manufactures in New York as late as 1731. Bishop quotes Governor Cosby as stating in 1734 that "as yet no iron work is set up in this province."

The first iron works in New York of which we have authentic information were "set up," according to Bishop, a short time prior to 1740, on Ancram creek, in Columbia county, about fourteen miles east of the Hudson river, by Philip Livingston, the owner of the Livingston manor. The works when completed embraced a blast furnace and refinery forge. The supply of ore was obtained mainly from the "ore hill" in Salisbury township, Litchfield county, Connecticut, of which Mr. Livingston was a principal owner, and which had been developed a few years previously. The ore mines were about twelve miles distant from the Ancram works. Other sources of ore supply were found in the eastern part of the manor, near the Massachusetts and Connecticut lines. Notwithstanding the inconvenient location of the works, at a considerable distance from the mines and also from the nearest point of shipment on the Hudson river for the manufactured iron, they were prosperous until after the Revolution. In 1756 they are said to have been the only iron works in the province that were then in operation, although others had been undertaken. Of these silent or unfortunate enterprises Bishop mentions two furnaces in the manor of Cortland, and "several bloomaries which had not been worked for several years." At Marysburg, in the Livingston manor, were some

forges which were operated about the time of the Revolution. Philip Livingston was one of the signers of the Declaration of Independence. He died in 1778, at York, Pennsylvania, while serving as a delegate to Congress, and is buried there.

Peter Kalm, the Swedish traveler, writing in 1748, says of the commerce of New York: "Of late years they have shipped a quantity of iron to England." Some of this iron was doubtless made in Connecticut and New Jersey. Douglass, in his *British Settlements*, written in 1750, speaking of New York, says: "The article of iron in pigs and bars is a growing affair."

Bishop says that iron works were established in Orange county prior to 1750, but by whom he does not state. In 1750 Governor Clinton reported that, at a place called Wawayanda, in Orange county, about twenty-six miles from the Hudson, there was a plating-forge with a tilt-hammer, which had been built four or five years before, but was not then in use. It was the property of Lawrence Scrawley, a blacksmith. "It was the only mill of that kind in the province. There was no rolling or slitting mill or steel furnace at that time in the province."

In 1750 a vein of magnetic iron ore was discovered on Sterling mountain, in Orange county, and in 1751 Ward & Colton built a furnace at the outlet of Sterling pond. In Eager's *History of Orange County* it is stated that "at the early establishment of this furnace the charcoal used was transported several miles on the backs of horses from the mountains where it was burned, there being no roads at the time." Bishop says that in 1752 "Abel Noble, from Bucks county, Pennsylvania, erected a forge in Monroe, near the furnace, at which anchors are said to have been made." Eager says that the first anchor made in New York was made at this forge in 1753. In 1765 William Hawkhurst published an advertisement stating that he had lately erected "a finery and great hammer for refining the Sterling pig iron into bars," but the location of this enterprise is not mentioned. The furnace of Ward & Colton and the forge of Abel Noble became the property of Peter Townsend before the Revolution. They had been named the Sterling iron works, presumably after Lord Stirling, the owner of the land, who became a general in the

Continental army, and who was engaged in the manufacture of iron in New Jersey before the Revolution. He may have been a part owner of the Orange county enterprises. (The Sterling works have always been spelled as here given, but Lord Stirling's name was differently spelled.) In 1773 Mr. Townsend made anchors at Sterling. We are informed by Mr. A. W. Humphreys that the anchors of the United States frigate *Constitution* were made here, and also the anchors for the first ships of war that carried the stars and stripes. In 1777 "the Townsends" had two forges with eight forge fires. In 1776 Mr. Townsend, according to Bishop, "produced the first steel in the province, at first from pig and afterwards from bar iron, in the German manner." Bishop also says that "the first blister steel made in the State was made by Peter Townsend, Jr., in 1810, from ore of the Long mine on the Sterling estate," but we assume that blister steel was made by the elder Townsend in 1776. The Long mine was discovered in 1761 by David Jones. Other valuable mines than those mentioned were discovered and opened on the Sterling estate in the last century. In 1777 a second Sterling furnace was erected by "the Townsends," and in 1806 Southfield furnace was built by them about six miles distant from the Sterling mines, and it is still standing. The two early Sterling furnaces have been replaced by one modern furnace.

Other mines of iron ore were discovered in Orange county during the last century, and many furnaces and forges were built in connection with them which have long been abandoned. In 1756 there was a Forest of Dean furnace five miles west of Fort Montgomery, which was supplied with ore from the Forest of Dean mine, near which it stood. The furnace was abandoned twenty-one years later. Eager says that "Captain Solomon Townsend, a cousin of Peter Townsend, and who married his daughter Anne in 1783, purchased the mountain estate adjoining that of his father-in-law, which he named Augusta, and established the iron works, anchory, forges, etc., at the place." These works were on the Ramapo, three miles above the Orange county line, in Orange county. There was a forge and anchory on Murderer's creek during the Revolution, owned by Samuel Brewster; after the war they passed into the hands of his son-in-law, Jonas Williams. Queens-

borough furnace, which went out of blast about 1800, and which was built to make pig iron, and not castings, was located about two and a half miles southwest of Fort Montgomery. On the stream issuing from Hazzard's pond there was a furnace named Woodbury about the beginning of this century.

During the last century Orange county was the chief seat of the iron manufacture in New York. Greenwood furnace, in this county, was erected in 1811 by the Messrs. Cunningham. In 1871 it was the only charcoal furnace in blast in Southern New York; since that year it also has been silent.

The following account of the great iron chain which was suspended across the Hudson river in 1778, to prevent the passage of the British vessels, is compiled from Lossing's *Field Book of the Revolution.*

At the close of 1779 West Point was the strongest military post in America. In addition to the batteries that stood menacingly upon the hill tops, the river was obstructed by an enormous iron chain. The iron of which this chain was constructed was wrought from ore of equal parts from the Sterling and Long mines, in Orange county. The chain was manufactured by Peter Townsend, of Chester, at the Sterling iron works, in the same county, which were situated about twenty-five miles back of West Point. The general superintendent of the work, as engineer, was Captain Thomas Machin, who afterwards assisted in the engineering operations at Yorktown, when Cornwallis was captured. The chain was completed about the middle of April, 1778, and on the 1st of May it was stretched across the river and secured.

Colonel Timothy Pickering, accompanied by Captain Machin, arrived at the house of Mr. Townsend late on a Saturday night in March of that year, to engage him to make the chain. Townsend readily agreed to construct it, and in a violent snow-storm, amid the darkness of the night, the parties set out for the Sterling iron works. At daylight on Sunday morning the forges were in operation. New England teamsters carried the links, as fast as they were finished, to West Point, and in the space of six weeks the whole chain was completed. It weighed 180 tons.

The chain was stretched across the river at the narrowest point between the rocks just below the steamboat landing and Constitution Island opposite. It was fixed to huge blocks on each shore, and under the cover of batteries on both sides of the river. The remains of these are still visible. "It is buoyed up," says Dr. Thacher, writing in 1780, "by very large logs of about sixteen feet long, pointed at the ends, to lessen their opposition to the force of the current at flood and ebb tide. The logs are placed at short distances from each other, the chain carried over them, and made fast to each by staples. There are also a number of anchors dropped at proper distances, with cables made fast to the chain, to give it greater stability."

Mr. Lossing describes a visit which he made in October, 1848, to West Point, where he saw a portion of the famous chain. He says: "There are twelve links, two clevises, and a portion of a link of the great chain remaining. The links are made of iron bars, two and a half inches square, average in length a little over two feet, and weigh about one hundred pounds each." The British vessels did not pass West Point. The manufacture of this chain was a great achievement. The Sterling forges, at which the chain was made, are no longer in operation, but the Sterling works as a whole are now the oldest active iron works in New York. Two other iron chains were stretched across the Hudson during the war to obstruct its passage. One of these was at the mouth of Murderer's creek, the iron for which was made at the forge of Jonas Williams. The other chain was at Fort Montgomery. This chain was broken by the British in 1777.

The following description of the Sterling works, which were the most extensive in New York until after the beginning of the present century, is translated from a book published at Paris in 1801, and lately discovered in that city by Mr. O. H. Marshall, a gentleman of antiquarian tastes, of Buffalo, New York. It was written by the Marquis de Creve-Cœur, who was in the French service in the French and Indian war, and afterwards traveled extensively in this country.

Hardly had we put our horses in the stable than Mr. Townsend, the proprietor, came to meet us with the politeness of a man of the world. Having learned that the object of our journey was to examine attentively his different works, he offered to show us all the details, and at once led us to his large furnace where the ore was melted and converted into pigs of 60 to 100 pounds' weight. The blast was supplied by two immense wooden blowers, neither iron nor leather being used in their construction. This furnace, he said, produced from 2,000 to 2,400 tons annually, three-fourths of which are converted into bars, the rest melted into cannon and cannon balls, &c. From there we went to see the forge. Six large hammers were occupied in forging bar iron and anchors and various pieces used on vessels.

Lower down the stream (which afforded power to the works) was the foundry, with its reverberatory furnace (air furnace). Here he called our attention to several ingenious machines destined for different uses. The models had been sent him, and the machines he had cast from iron of a recently discovered ore, which after two fusions acquired great fineness. With it he could do the lightest and most delicate work. "What a pity," he said, "that you did not come ten days sooner. I would have shown you, first, three new styles of plows, of which I have cast the largest pieces, and

which, however, are no heavier than the old-fashioned. Each one of them is provided with a kind of steel yard, so graduated that one can tell the power of the team and the resistance of the soil. Second, I would have shown you a portable mill for separating the grain from the chaff, followed by another machine by which all the ears in the field can be easily gathered without being obliged to cut the stalk at the foot, according to the old method."

From the foundry we went to see the furnaces where the iron is converted into steel. "It is not yet as good as the Swedes," said Mr. T., "but we approach it—a few years more of experience and we will arrive at perfection. The iron which comes from under my hammers has had for a long time a high reputation and sells for £28 to £30 per ton." After having passed two days in examining these divers works and admiring the skill with which they were supplied with water, as well as the arrangements for furnishing the charcoal for the different furnaces, we parted from Mr. Townsend.

In 1765 there were iron works in Dutchess county. A furnace and foundry at Amenia in this county were in operation during the Revolution, "at which steel and castings were made for the use of the army." A bloomary was in operation about the period of the Revolution at Patchogue, in Brookhaven township, Suffolk county, Long Island. At Riverhead, in Suffolk county, Captain Solomon Townsend established "a manufactory of bar iron" before the close of the last century. Iron ore was mined in Putnam county in the last century, some of which was taken to iron works on Long Island sound. In the manor of Philipsburg, in Westchester county, iron ore was mined and furnaces were erected before the close of the same century. About the time of the Revolution a furnace named Haverstraw and several bloomaries were in existence in Rockland county, on the western side of the Tappan Zee.

About the year 1800 the celebrated Champlain iron district was developed, and in 1801 the first iron works in the district were built at Willsborough Falls, on the Boquet river, in Essex county, to manufacture anchors. George Throop, Levi Highly, and Charles Kane were the owners. Among other early iron enterprises in this district were the New Russia, Jay, and Elba forges in Essex county, and the Eagle rolling mill at Keeseville, in Clinton county. This district has been for a long time the most important iron district in the State. In 1883 it contained 6 rolling mills, 6 blast furnaces, and 27 forges. These forges are all true bloomaries, manufac-

turing blooms directly from the rich magnetic and specular ores of the neighborhood. The district comprises the counties of Essex, Clinton, and Franklin. It possesses the same mineral characteristics as the celebrated iron district in Western Vermont which has already been referred to. A forge was built at West Fort Ann, in Washington county, south of Lake George, about 1802, which used ore of precisely the same character as that obtained in the Champlain and Vermont districts.

It has already been stated that the Catalan forge, for the manufacture of iron directly from the ore, is still in use in the United States. In some of the Southern States it is used in the simple and inexpensive form in which it appears to have been introduced into this country, and which is known among metallurgists as the German bloomary. But in the Champlain district of New York the old Catalan forge, or German bloomary, has been greatly improved, so much so that the bloomary in use in this district, with its expensive machinery and uniform product, may well be styled the American bloomary. It is fully described by Professor Thomas Egleston, in a paper in the *Transactions of the American Institute of Mining Engineers*, volume VIII. The blast is heated, which was never done with the old Catalan forge, but most of the power is still supplied by a water-wheel. Charcoal is the only fuel used, and great care is taken in its manufacture, as well as in calcining the ore, which is of a very pure quality. The bloom produced in this forge usually weighs from 300 to 400 pounds. From the blooms are obtained billets of refined iron, which go into consumption in the manufacture of crucible and open-hearth steel, iron wire, plate and sheet iron, etc. About one ton of billets is produced at each forge in twenty-four hours. The blooms and billets are hammered into shape by a trip-hammer. As stated above, there were in 1883 in the Champlain district 27 forges, or bloomaries, for the manufacture of blooms. These embraced 171 forge fires. In the census year 1880 there were only 22 forges, with 141 fires, and they produced 31,580 net tons of blooms in that year. The production of Champlain blooms has increased from 23,666 net tons in 1875 to 43,911 tons in the calendar year 1882.

West of the Champlain district, in the counties of Saint Lawrence, Jefferson, Lewis, Oswego, and Oneida, many char-

coal furnaces were built after the beginning of the present century, among the earliest of which were Rossie furnace in Saint Lawrence county, Taberg furnace in Oneida county, and Constantia furnace in Oswego county. In the extreme western and southwestern parts of the State the few iron enterprises that have had an existence during the present century have all been of yet more modern origin.

Nails were extensively manufactured by hand at Albany in 1787. Twenty years later, in 1807, John Brinkerhoff, of Albany, lighted the fires in his newly-erected rolling mill on the Wynantskill. The Troy *Daily Times* says that "the operations of the little wooden rolling mill built by him were confined to converting Russian and Swedish bar iron into plates, which were slit into narrow strips, and these cut to the required length and made into nails by hand." In 1826 the nail factory of John Brinkerhoff was sold at auction and purchased for $5,280 by Erastus Corning, who was then engaged at Albany in the hardware business. It now forms part of the works of the Albany and Rensselaer Iron and Steel Company, the most extensive and important iron and steel works in the State.

Between 1790 and 1800 there are said to have been twenty-three patents granted in the United States for nail-making machinery, and down to 1825 the whole number granted is said to have been one hundred and twenty. Among these patents was one issued to Josiah G. Pierson, of New York, on the 23d of March, 1795, and the machine covered by this patent is said to have been the first nail-cutting machine that produced satisfactory results and was generally used. The inventor was at the time a member of the firm of J. G. Pierson & Brothers, which in the same year established works at the village of Ramapo, in Rockland county, New York, for the manufacture of iron and nails, and had previously, in 1787 or 1788, been engaged in the manufacture of cut nails, with an imperfect machine, in Whitehall street, in the city of New York. While the works were in New York the strips for the nails were rolled and slit at a mill near Wilmington, in Delaware, to which Swedish and Russian iron were sent, no other mill being available at the time. This inconvenience was avoided after the establishment of the works at Ramapo,

which included a rolling and slitting mill. The manufacture of nails by Mr. Pierson's machine was here actively prosecuted until about 1830, when the same firm, which had been making blister steel at Hoboken for twenty years, removed its steel furnaces to Ramapo, and substituted the manufacture of spring steel for that of nails. The works of the Messrs. Pierson at Ramapo have been succeeded by those of the celebrated Ramapo Wheel and Foundry Company.

The iron industry of New York was not so prominent during the eighteenth century as that of some other States, but soon after the beginning of the present century the development of the Champlain district gave to the industry more prominence, which was still further increased after 1840, when anthracite coal was applied to the manufacture of pig iron on the Hudson river and elsewhere in the State. In 1870, and again in 1880, New York ranked third in the list of iron and steel producing States, Pennsylvania being first and Ohio second in the list in both years.

CHAPTER X.

EARLY IRON ENTERPRISES IN NEW JERSEY.

In William Reed Deane's *Genealogical Memoirs of the Leonard Family*, already referred to, it is stated that Henry Leonard left Rowley Village, Massachusetts, early in 1674, "and at that time, or soon after, went to New Jersey, establishing the iron manufacture in that State." His sons Samuel, Nathaniel, and Thomas probably left Rowley Village soon after their father's departure, and followed him to New Jersey. Bishop says that Shrewsbury, a township lying northwest of Long Branch, in Monmouth county, was settled by Connecticut people soon after New Jersey was surrendered to the English by the Dutch in 1664, and that it was "to this part of Jersey" that Henry Leonard removed. About the time of the Connecticut settlement, James Grover, who had been a resident of Long Island, also settled in Shrewsbury, and is said to have established iron works in that township, which he afterwards sold to Colonel Lewis Morris, then a merchant of Barbadoes, but born in England. On October 26, 1676, a grant of land was made to Colonel Morris, with full liberty to him and his heirs "to dig, delve, and carry away all such mines for iron as they shall find or see fit to dig and carry away to the iron work," which grant establishes the fact that the iron works in Shrewsbury were built prior to 1676, and that they were then owned by Colonel Morris. They were probably undertaken about 1674, in which year Henry Leonard is said to have emigrated from Massachusetts to New Jersey. They were the first iron works in New Jersey.

In a brief account of the province of East Jersey, published by the proprietors in 1682, it is stated that "there is already a smelting furnace and forge set up in this colony, where is made good iron, which is of great benefit to the country." Smith, in his *History of New Jersey*, says that in 1682 "Shrewsbury, near Sandy Hook, adjoining the river or creek of that name, was already a township, consisting of several thousand acres, with large plantations contiguous; the inhabitants were

computed to be about 400. Lewis Morris, of Barbadoes, had iron works and other considerable improvements here." In 1685 it was stated in *The Model of the Government of East New Jersey* that "there is an iron work already set up, where there is good iron made." In the same year Thomas Budd, in his *Good Order in Pennsylvania and New Jersey*, wrote that there was but one iron work in New Jersey, and that this was located in Monmouth county. All of these statements refer to the Shrewsbury works, which do not seem to have had a long life. According to Oldmixon they were located between the towns of Shrewsbury and Middletown; other authorities more definitely locate them at Tinton Falls. They used bog ore.

The rich deposits of magnetic iron ore in Northern New Jersey were discovered at an early day, and about 1710, as we are informed by the Rev. Dr. Joseph F. Tuttle, in his *Early History of Morris County*, written in 1869, settlements were made on the Whippany river, in Hanover township, in Morris county, and at a place now called Whippany, four miles northeast of Morristown, a forge was erected, but by whom is not now known. Bishop says that the first settlers of Hanover located there "for the purpose of smelting the iron ores in the neighborhood." They "early erected several forges and engaged extensively in the iron manufacture." Whippany is about fifteen miles east of the celebrated Succasunna iron-ore mine, in the present township of Randolph, and it was here that the settlers obtained their supply of iron ore. The ore was carried to the works in leather bags on pack-horses, and the bar iron was carried on horseback over the Orange mountains to Newark. Bishop says that "forges at Morristown, and some in Essex county, were long supplied in the same way from the rich ore of the mine. The ore was for some time free to all." This celebrated iron-ore deposit has long been known as the "Dickerson mine," so called after the Hon. Mahlon Dickerson, who was Governor of New Jersey in the early part of this century, and was subsequently and for many years a United States Senator from the same State. Hon. Edmund D. Halsey, in the *History of Morris County*, says that "the tract embracing the Dickerson mine was taken up on account of its minerals" by John Reading in 1713 or 1714, who sold it to Joseph Kirkbride in 1716.

Dr. Tuttle says that in 1722 Joseph Latham sold a tract of land in the present township of Randolph, in Morris county, to "one John Jackson, who built a forge on the little stream which puts into the Rockaway near the residence of Mr. Jacob Hurd. The forge was nearly in front of Mr. Hurd's house," a mile west of Dover. Wood for charcoal was abundant, and the mine on the hill was not far distant. For some reason Jackson did not succeed in his iron enterprise, and was sold out by the sheriff in 1753. After his failure he is supposed to have removed to the western part of Virginia. "Jackson's iron works on Cheat river," in that State, mentioned by early writers, may have been established by him or his sons. Dr. Tuttle says that Rockaway was settled about 1725, or possibly as late as 1730, "at which time a small iron forge was built near where the upper forge now stands in Rockaway." This was the first forge at Rockaway. Mr. Halsey says that it was probably built by Job Allen; it was known as "Job Allen's iron works" in 1748. Dr. Tuttle adds that "forges were built on different streams, at Rockaway, Denmark, Middle Forge, Ninkee, Shaungum, Franklin, and other places from the year 1725 to 1770." At Troy, in Morris county, as we learn from another source, a forge was built in 1743, which was in operation as late as 1860. All of these forges were bloomaries, manufacturing bar iron from the ore. In 1751 many of these forges did not severally produce more than five or six tons of iron in a year.

At the close of the seventeenth century and for some years after the beginning of the eighteenth century New Jersey was the only colony outside of New England that was engaged in the manufacture of iron, and this manufacture was almost wholly confined to its bloomaries. The rich magnetic ores, the well-wooded hillsides, and the restless mountain streams of Northern New Jersey afforded every facility for the manufacture of iron of a superior quality by this primitive method, while the nearness of good markets furnished a sufficient inducement to engage in the business. The bloomaries of New Jersey were Catalan forges of the German type. Many of them were blown by the *trompe*, or water-blast.

Not much progress was made, however, in the establishment of the iron industry in New Jersey until the middle of

the eighteenth century. From about 1740 down to the Revolution many furnaces and other iron works were built in New Jersey. Its iron industry during the greater part of this period was exceedingly active, although hampered by restrictions imposed by the mother country. To the iron enterprises which were then built up within its borders the patriotic cause was afterwards greatly indebted for much of the iron and steel that was needed to secure its success.

Peter Hasenclever, a Prussian gentleman of distinction, who is usually referred to as Baron Hasenclever, emigrated to New Jersey about 1764, as the head of an iron company which he had organized in London, and brought with him a large number of German miners and ironworkers. His career in this country is very fully described by Dr. Tuttle in his history, and by Mr. Halsey in a letter which we have received from him. Dr. Tuttle first gives an account of the Ringwood Company, which was organized in 1740 and was principally composed of several persons named Ogden. In the year named the company purchased sixteen acres of land at Ringwood, near Greenwood lake, in Bergen (now Passaic) county, where, says Mr. Halsey, they built a furnace. In 1764 Joseph Board conveyed to the Ringwood Company a tract of land at Ringwood "near the old forge and dwelling house of Walter Erwin." On July 5, 1764, the Ringwood Company sold to "Peter Hasenclever, late of London, merchant," for £5,000, all of its lands and its improvements at Ringwood. The deed states that on the property there are "erected and standing a furnace, two forges, and several dwelling houses." It speaks of "Timothy Ward's forge;" also of the "old forge at Ringwood." Hasenclever also bought from various persons other tracts of land in 1764 at Ringwood and in its vicinity, and in 1765 he bought several tracts from Lord Stirling. These purchases were located at Ringwood, Pompton, Long Pond, and Charlottenburg, all in what was then Bergen county. Hasenclever also probably purchased an interest in the iron-ore mines at Hibernia. Dr. Tuttle says that "Hasenclever at once began to enlarge the old works and build new ones at each of the places just named," that is, Ringwood, Pompton, Long Pond, and Charlottenburg. It is probable that he built a furnace and one or more forges at each place.

Three furnaces and six forges he certainly erected. The furnaces were erected, respectively, as follows: Charlottenburg, on the west branch of the Pequannock; Ringwood, on the Ringwood branch of the Pequannock; Long Pond, on the Winockie, and about two miles from Greenwood lake. Charlottenburg was built in 1767, and was capable of producing from 20 to 25 tons of pig iron weekly. Long Pond was in blast in 1768.

Hasenclever undoubtedly succeeded in making good iron, some of which was shipped to England. He also made steel of good quality "directly from the ore." In 1768 he became financially embarrassed, and in 1770 was formally declared a bankrupt. He returned to Germany and became a successful linen manufacturer in Silesia. He was succeeded in the management of the company's estate by John Jacob Faesch, who had come to New Jersey with him, or soon after him, under an engagement as manager of the iron works for seven years. Faesch is said to have looked after his own interests more than those of the company. In 1771 or 1772 he was succeeded by Robert Erskine, a Scotchman, who appears to have met with success until 1776, when all the works were stopped by the opening of hostilities, and Charlottenburg furnace was burned, but whether accidentally or by opponents of the patriotic cause is not now known.

Robert Erskine was thoroughly loyal to the Revolutionary cause. He died at Ringwood in 1780, "and his grave occupies a retired spot about a quarter of a mile from the ruins of the old Ringwood furnace, near the road leading from Ringwood to West Milford." The inscription upon his tombstone reads: "In memory of Robert Erskine, F. R. S.; Geographer and Surveyor General to the Army of the United States; son of Rev. Ralph Erskine, late Minister at Dumferline, in Scotland. Born September 7, 1735. Died October 2, 1780, aged 45 years and 25 days." For some time he held a commission as captain in the New Jersey militia. New Jersey may well honor the memory of this early ironmaster.

The Adventure furnace, at Hibernia, in Morris county, was a famous furnace during the Revolution, casting ordnance and other iron supplies for the army. It was built in 1765. Mr. Halsey says that a tract of land was located on November 23,

1765, "about three-quarters of a mile above the new furnace called the Adventure." The name usually given to this furnace is Hibernia. Dr. Tuttle says that "the names of Lord Stirling, Benjamin Cooper, and Samuel Ford are connected with the original building and ownership of the Hibernia works." He also says that "Benjamin Cooper & Co." held "pew No. 6" in the old Rockaway meeting-house in 1768. A grant of certain privileges to encourage the enterprise was made by the legislature in 1769. In 1765 Ford sold his interest in the furnace to Anderson and Cooper, after which sale he was actively engaged for a number of years in the business of counterfeiting "Jersey bills of credit," which he afterwards pleasantly referred to as "a piece of engenuity." In 1768 he participated in the robbery of the treasury of the province at Amboy, his former partner, Cooper, being one of his associates. Ford was arrested in 1773, but escaped to Virginia; Cooper and others were also arrested and convicted, but all except one escaped punishment, and he was hanged. Previous to the time of his arrest, in 1773, Cooper appears to have sold his interest in Hibernia furnace to Lord Stirling, who became its sole owner about this time, Mr. Halsey thinks in 1771.

Mount Hope furnace, about four miles northwest of Rockaway, was built in 1772 by John Jacob Faesch, after he had severed his connection with the London Company. It was active until about 1825. It also was a noted furnace during the Revolution, casting shot and shells and cannon for the Continental army. In September, 1776, Joseph Hoff, who was then the manager of Hibernia furnace, wrote to Lord Stirling that Faesch had requested him "to inform you that he wanted 200 tons of pig metal, and wanted to know your price and terms of payment. Iron will undoubtedly be in great demand, as few works on the continent are doing anything this season." This letter indicates that at the time it was written Faesch owned or controlled a forge for converting pig iron into bar iron. Mr. Halsey says that he became the owner of Middle and Rockaway forges and the lessee of Mount Pleasant forge and the Boonton slitting mill. On the 14th of November, 1776, Hoff wrote to General Knox that there were 35 tons of shot at Hibernia furnace, and on the 21st of

November he wrote that it was the only furnace in New Jersey which he knew to be then in blast. The Hibernia and the Mount Hope furnaces were both in blast in 1777. Mr. Halsey informs us that among the laws of New Jersey for 1777 is an act, passed October 7th, exempting men to be employed at Mount Hope and Hibernia furnaces from military service, and reciting the necessity of providing the army and navy of the United States with cannon, cannon shot, etc., and that the works "have been for some time past employed" in providing such articles, and "are now under contract for a large quantity." Faesch is said by Dr. Tuttle to have become the lessee of Hibernia furnace at some time during the war. He says "this must have been subsequent to July 10, 1778, at which date I find a letter to Lord Stirling, from Charles Hoff, his manager at Hibernia, reporting to him what he was doing."

Faesch died at Old Boonton on May 29, 1799, and was buried at Morristown. Mr. Halsey says that he was born in the canton of Basle, in Switzerland, in 1729. Dr. Tuttle says that "in his day John Jacob Faesch was one of the great men of Morris county, regarded as its greatest ironmaster, one of its richest men, and one of its most loyal citizens." General Washington and his staff once visited him at Mount Hope.

Lord Stirling, whose proper name was William Alexander, was born in the city of New York in 1726 and died at Albany in 1783. As has been shown in the chapter relating to New York, his name has been given to one of the oldest and most successful iron enterprises in the country.

Colonel Jacob Ford, Sr., was a large landholder in Morris county about the middle of the last century. In 1750 he built two forges, probably a finery and chafery, at Mount Pleasant, three miles west of Rockaway. There was a forge at this place as late as 1856, but almost in ruins. In 1764 John Harriman owned a forge called Burnt Meadow forge, at Denmark, about five miles north of Rockaway, of which Colonel Jacob Ford, Jr., afterwards became the owner. It was probably built by Colonel Jacob Ford, Sr., about 1750. Colonel Ford, Jr., about 1764 became the owner of the forge below Denmark and above Mount Pleasant, called ever since Middle forge, which was built by Jonathan Osborn in 1749. The United States now

owns the site of the forge last mentioned. John Johnston had "iron works" at Horse Pound, now Beach Glen, a mile and a half below Hibernia, from 1753 to 1765, as appears from references to them in the title papers of adjoining lands.

In Andover township, in Sussex county, a furnace and a forge were erected by a strong company before the Revolution, probably about 1760, and the works were operated on an extensive scale. About the beginning of hostilities the works were stopped, the company being principally composed of royalists. The excellent quality of the iron made from the ore of the Andover mine led, however, to such legislation by Congress in January, 1778, as resulted in again putting them in operation. Mr. Whitehead Humphreys, of Philadelphia, was directed by Congress to make steel for the use of the army from Andover iron, as the iron made at the Andover works was the only iron which would "with certainty answer the purpose of making steel." This action of Congress is given in detail by the Hon. Jacob W. Miller, in an address before the New Jersey Historical Society in 1854, who also records the interesting fact that William Penn was an early owner of the Andover mine. He says that, "on the 10th of March, 1714, by a warrant from the council of proprietors, he acquired title to a large tract of land, situated among the mountains, then of Hunterton, now of Sussex, county, and William Penn became the owner of one of the richest mines of iron ore in New Jersey. This mine, since called Andover, was opened and worked to a considerable extent as early as 1760. Tradition reveals to us that the products of these works were carried upon pack-horses and carts down the valley of the Musconetcong to a place on the Delaware called Durham, and were thence transported to Philadelphia in boats, which were remarkable for their beauty and model, and are known as Durham boats to this day."

Franklin furnace, near Hamburg, in Sussex county, which was built in 1770 and abandoned about 1860, has been succeeded by one of the largest anthracite furnaces in the country —67 feet high and $20\frac{1}{2}$ feet wide at the boshes.

Israel Acrelius, the historian of New Sweden, who resided in this country from 1750 to 1756, mentions five iron enterprises as then existing in New Jersey—the Union iron works,

and Oxford, Sterling, Ogden's, and Mount Holly furnaces. Oxford furnace, on a branch of the Pequest river, at Oxford, in Warren county, was built by Jonathan Robeson in 1742. Tradition says that it was first blown by a water-blast. A pig of Oxford iron, bearing the date "1755," is now in possession of the Historical Society, at Trenton. Oxford cannon balls, cast during the French war, have also been preserved. Cannon balls were cast at this furnace for the Continental army. The furnace is still standing and was in operation in 1880, using anthracite coal. It is the second furnace in New Jersey of which there is any exact record, Shrewsbury being the first. In 1880 it divided with Cornwall furnace, in Pennsylvania, the honor of being the oldest furnace in the United States that was then in operation. The Union iron works were situated near Clinton, in Hunterton county, and embraced at the time of Acrelius's visit two furnaces and two forges, "each with two stacks;" also a trip-hammer and a "flatting-hammer." These works were then owned by William Allen and Joseph Turner, both of Philadelphia. William Allen was the chief justice of Pennsylvania from 1751 to 1774. Allentown, in Pennsylvania, was named after him. He was largely interested in the manufacture of iron in Pennsylvania and New Jersey. In October, 1775, he gave his "half of a quantity of cannon shot belonging to him and to Turner for the use of the Board of the Council of Safety;" but he remained loyal to the British crown, nevertheless, dying in London in 1780. The Union iron works appear to have been entirely abandoned in 1778. Judge Allen informed Acrelius that at these works, and also at Durham, (a Pennsylvania furnace,) one and a half tons of iron ore yielded one ton of pig iron; and that a good furnace yielded from twenty to twenty-five tons of pig iron every week. Ogden's furnace was situated near Newton, in Sussex county. Mount Holly furnace was situated at the town of that name, in Burlington county. It was built between 1730 and 1747, and is probably as old as Oxford furnace. A forge was connected with the furnace. The works stood where the saw-mill at the south end of Pine street, on Rancocas creek, now stands. All of the furnaces named, except Mount Holly, used magnetic ore; Mount Holly, according to Acrelius, used "brittle bog ore in gravel," which was

"only serviceable for castings." But the existence of the forge and the further fact that pig iron has been found in the ruins of the works show that the ore was used for something else than castings. The furnace was in operation before and partly through the Revolution. It was destroyed by the British during that period. Acrelius mentions, but does not name, four bloomaries in New Jersey, all "in full blast" during his visit. The Sterling furnace referred to by him was Sterling furnace in New York, but this furnace, particulars of which have already been given, was then probably embraced within the boundaries of New Jersey. Acrelius's list of iron enterprises in New Jersey in his day is incomplete.

On November 10, 1750, Governor Belcher certified that there were in New Jersey "one mill or engine for slitting and rolling of iron, situate in the township of Bethlehem, in the county of Hunterton, on the south branch of the river Raritan, the property of Messrs. William Allen and Joseph Turner, of Philadelphia, which is not now in use; one plating-forge, which works with a tilt-hammer, situate on a small brook at the west end of Trenton, the property of Benjamin Yard, of Hunterton, which is now used; one furnace for the making of steel, situate in Trenton, the property of Benjamin Yard, which is not now used." Steel was, however, made at Trenton during the Revolution. A rolling and slitting mill was built at Old Boonton, in Morris county, before the Revolution, probably about 1770, by a member of the Ogden family. A second rolling and slitting mill was built at Speedwell, about the beginning of the Revolution, by Jacob Arnold and John Kinney, but this enterprise was a failure. A more successful enterprise of the same kind was established at Dover, in the same county, about 1792, by Israel Canfield and Jacob Losey, who also added a factory for cutting nails, which were headed by hand in dies. In 1800 there were in this county three rolling and slitting mills, two furnaces, "and about forty forges with two to four fires each."

Mr. Halsey furnishes us with the following interesting episode in the history of the Old Boonton slitting mill: "A slitting mill was erected at Old Boonton, on the Rockaway river, about a mile below the present town of Boonton, in defiance of the law, by Samuel Ogden, of Newark, with the aid of his

father. The entrance was from the hillside, and in the upper room first entered there were stones for grinding grain, the slitting mill being below and out of sight. It is said that Governor William Franklin visited the place suddenly, having heard a rumor of its existence, but was so hospitably entertained by Mr. Ogden, and the iron works were so effectually concealed, that the Governor came away saying he was glad to find that it was a groundless report, as he had always supposed."

In the southern part of New Jersey several small furnaces were built at an early day to smelt the bog ore of that section. Of these the furnace at Mount Holly, already mentioned, was probably the oldest. Batsto furnace, also in Burlington county, was built about 1766 by Charles Reed, and cast shot and shells for the Continental army. Many bloomaries were also built in this section in the last century, to work bog ore. The "Jersey pines" furnished the fuel for both the furnaces and bloomaries. It was stated in the chapter relating to New England iron enterprises in the last century that ore was taken from Egg Harbor, in New Jersey, to supply some Massachusetts furnaces. This was bog ore. Batsto furnace was situated on Little Egg Harbor river, and ran until after the middle of the present century. Sheet iron was made at the forge at Mount Holly in 1775, by Thomas Mayburry, some of which was used to make camp-kettles for the Continental army. A nail factory was in operation at Burlington in 1797. In 1814 or 1815 Benjamin and David Reeves, brothers, established the Cumberland nail and iron works at Bridgeton, in Cumberland county, and for many years successfully manufactured nails, with which they largely supplied the eastern markets. These works are still in operation. In 1820 there was a rolling mill at Paterson, (Colt's,) which was leased by Colonel Joseph Jackson, of Rockaway, and his brother William, and at which they rolled round and square iron. It is important to note the year in which the Jackson brothers rolled this iron, as the rolling of iron, except in connection with slitting mills, had but recently been introduced into this country. The Jacksons were pioneers in this important innovation. In 1822 they built the first rolling mill at Rockaway.

Peter Cooper engaged in the manufacture of iron at Tren-

ton, New Jersey, in 1845, where, as is stated by the *American Cyclopædia*, "he erected the largest rolling mill at that time in the United States for the manufacture of railroad iron, and at which subsequently he was the first to roll wrought-iron beams for fire-proof buildings." He had previously, however, been prominently engaged in the manufacture of iron at Baltimore and at New York City. In connection with members of his family he also embarked in many other important iron enterprises in New Jersey. His name has been the most prominent and the most honored in the iron history of the State during the present century.

Peter Cooper was born in New York City on February 12, 1791, and died at the residence of his son-in-law, Hon. Abram S. Hewitt, in the same city, on April 4, 1883, aged 92 years, 1 month, and 23 days.

In 1784 New Jersey had eight furnaces and seventy-nine forges and bloomaries, but principally bloomaries. In 1802 there were in New Jersey, according to a memorial to Congress adopted in that year, 150 forges, "which, at a moderate calculation, would produce twenty tons of bar iron each annually, amounting to 3,000 tons." At the same time there were in the State seven blast furnaces in operation and six that were out of blast; also four rolling and slitting mills, "which rolled and slit on an average 200 tons, one-half of which was manufactured into nails." Of the forges mentioned, about 120 were in Morris, Sussex, and Bergen counties. Of the numerous charcoal furnaces which once dotted New Jersey not one now remains which uses charcoal, the introduction of anthracite coal in the smelting of iron ore, which took place about 1840, rendering the further production of charcoal pig iron in New Jersey unprofitable. The last charcoal furnace erected in the State was built at Split Rock, in Morris county, by the late Andrew B. Cobb, about 1862, but it was soon abandoned. Only two or three of the old bloomaries of New Jersey now remain, although there are in the State a few bloomaries and forges of modern origin, as well as a large number of rolling mills, steel works, wire works, pipe works, and anthracite furnaces.

In 1870 New Jersey was fourth in rank among the iron-producing States, but in 1880 it had fallen to the fifth place.

CHAPTER XI.

THE MANUFACTURE OF IRON IN PENNSYLVANIA BEFORE THE REVOLUTION.

The settlers on the Delaware, under the successive administrations of the Swedes and Dutch and the Duke of York, down to 1682, appear to have made no effort to manufacture iron in any form. In the *Journal of a Voyage to New York* in 1679 and 1680, by Jasper Dankers and Peter Sluyter, who then visited the Swedish and other settlements on the Delaware, it is expressly declared that iron ore had not been seen by them on Tinicum Island or elsewhere in the neighborhood. Jasper Dankers says: "As to there being a mine of iron ore upon it, I have not seen any upon that island, or elsewhere; and if it were so it is of no great importance, for such mines are so common in this country that little account is made of them."

Under the more energetic rule of William Penn, who sailed up the Delaware in the ship *Welcome* in 1682, the manufacture of iron in Pennsylvania had its beginning. In a letter written by Penn to Lord Keeper North, in July, 1683, he mentions the existence of "mineral of copper and iron in divers places" in Pennsylvnaia. In his *Further Account of the Province of Pennsylvania*, written in 1685, speaking of "things that we have in prospect for staples of trade," he says: "I might add iron, (perhaps copper, too,) for there is much mine, and it will be granted us that we want no wood." In a letter to James Logan, the secretary of the province, dated London, April 21, 1702, he says, under the heading of "*Iron Works:*" "Call on those people for an answer to the heads I gave them from Ambrose Crawley. Divers would engage here in it as soon as they receive an account, which, in a time of war, would serve the country. Things as to America will come under another regulation after a while." To this letter Logan replied from Philadelphia, under date of October 1, 1702, as follows: "I have spoke to the chief of those concerned in the iron mines, but they seem careless, having never had a meet-

ing since thy departure; their answer is that they have not yet found any considerable vein." Smiles, in his *Industrial Biography*, says: "William Penn, the courtier Quaker, had iron furnaces at Hawkhurst and other places in Sussex." It was, therefore, but natural that he should encourage the manufacture of iron in his province, and it was certainly through no indifference or neglect of his that it was not established at an early day in its history.

In 1692 we find the first mention of iron having been made in Pennsylvania. It is contained in a metrical composition entitled *A Short Description of Pennsylvania,* by Richard Frame, which was printed and sold by William Bradford, in Philadelphia, in 1692. Frame says that at "a certain place about some forty pound" of iron had then been made. The entire reference is as follows:

> A certain place here is, where some begun
> To try some Mettle, and have made it run,
> Wherein was Iron absolutely found,
> At once was known about some Forty Pound.

It is to be regretted that Frame was not more explicit in describing the place where this iron was made. It was possibly made in a bloomary fire—probably in a blacksmith's fire.

In 1698 Gabriel Thomas printed at London *An Historical and Geographical Account of the Province and Country of Pennsylvania and of West New Jersey in America,* in which mention is made of the mineral productions of these colonies. Alluding to Pennsylvania, he says: "There is likewise ironstone or ore, lately found, which far exceeds that in England, being richer and less drossy. Some preparations have been made to carry on an iron work." But neither these preparations nor the enterprise alluded to by Richard Frame led to satisfactory results.

Mrs. James, in her *Memorial of Thomas Potts, Junior,* gives an account of the first successful attempt that was made to establish iron works in Pennsylvania. The event, which occurred in 1716, is briefly described in one of Jonathan Dickinson's letters, written in 1717, and which we have seen: "This last summer one Thomas Rutter, a smith, who lives not far from Germantown, hath removed further up in the country,

and of his own strength hath set upon making iron. Such it proves to be, as is highly set by by all the smiths here, who say that the best of Sweed's iron doth not exceed it; and we have accounts of others that are going on with iron works." Rutter's enterprise was a bloomary forge, located on Manatawny creek, in Berks county, about three miles above Pottstown. The name of this first forge is uncertain. Mrs. James says that the name was Pool forge. There was certainly a Pool forge on the Manatawny as early as 1728, in which year it is mentioned in Thomas Rutter's will. The name of Rutter's pioneer enterprise may, however, have been Manatawny. In the Philadelphia *Weekly Mercury* for November 1, 1720, Thomas Fare, a Welshman, is said to have run away from "the forge at Manatawny." Bishop says: "A forge is mentioned in March, 1719–'20, at Manatawny, then in Philadelphia, but now in Berks or Montgomery, county. It was attacked by the Indians in 1728, but they were repulsed with great loss by the workmen."

Mrs. James says that Rutter was an English Quaker, who was a resident of Philadelphia in 1685, and who removed in 1714 from Germantown "forty miles up the Schuylkill, in order to work the iron mines of the Manatawny region." She gives a *verbatim* copy of the original patent of William Penn to Thomas Rutter for 300 acres of land "on Manatawny creek," dated February 12, 1714–'15.

The following obituary notice in the *Pennsylvania Gazette*, published at Philadelphia, dated March 5 to March 13, 1729–'30, ought to be conclusive proof of the priority of Thomas Rutter's enterprise: "Philadelphia, March 13. On Sunday night last died here Thomas Rutter, Senior, of a short illness. *He was the first that erected an iron work in Pennsylvania.*" In his will, which we have examined, he is styled a blacksmith. Many of his descendants have been prominent Pennsylvania ironmasters. Mrs. James says that Dr. Benjamin Rush, a signer of the Declaration of Independence, was a great-grandson of Thomas Rutter.

The next iron enterprise in Pennsylvania was Coventry forge, on French creek, in the northern part of Chester county, which was built by Samuel Nutt, also an English Quaker. Egle's *History of Pennsylvania* says that Nutt arrived in the

province in 1714, and that "he took up land on French creek in 1717, and about that time built a forge there. A letter written by him in 1720 mentions an intention of erecting another forge that fall." We have seen this letter, which is dated July 2, 1720. It is written in Friends' language. Nutt proposed to build the new forge on French creek. Mrs. James states that Nutt purchased 800 acres of land at Coventry in October, 1718. This was in addition to his earlier purchases. He probably made iron at Coventry forge in that year. Bishop refers to a letter written by Dickinson, in July, 1718, stating that "the expectations from the iron works forty miles up the Schuylkill are very great." In April, 1719, Dickinson again wrote: "Our iron promises well. What hath been sent over to England hath been greatly approved. Our smiths work up all they make, and it is as good as the best Swedish iron." Dickinson probably referred to Nutt's forge as well as to Rutter's. The former, as well as the latter, doubtless at first made bar iron directly from the ore.

Coventry forge was in operation in 1756, and in 1770 it is noted on William Scull's map of Pennsylvania. It was in active operation after the Revolution, and in 1849 and 1856 we again find it active. It made its last iron in 1870. It is the oldest existing iron work in the State, and has been owned by the Chrisman family for over eighty years.

The next iron enterprise in Pennsylvania was undoubtedly Colebrookdale furnace, which was erected about 1720 by a company of which Thomas Rutter was the principal member. It was located on Ironstone creek, in Colebrookdale township, in Berks county, about eight miles north of Pottstown, three-fourths of a mile west of Boyertown, and about two hundred yards from the Colebrookdale Railroad. Plenty of cinder marks the exact site to-day. A large grist and saw mill stands about one hundred feet distant. This furnace supplied Pool forge with pig iron, and in course of time other forges. The Colebrookdale company appears to have been composed of Thomas Rutter, James Lewis, Anthony Morris, and others, Rutter owning a two-thirds interest, as is shown by his will, on file in the office of the register of wills in Philadelphia.

In 1731, according to Mrs. James, Colebrookdale furnace and Pool forge were both owned by companies. In the list of

owners of both establishments appears the name of Thomas Potts, the founder of a family of the same name which has ever since been prominent in the manufacture of iron in Pennsylvania and in other States. He died at Colebrookdale in January, 1752. He was in his day the most successful iron manufacturer in Pennsylvania. In his will, dated 1747, he leaves his "two-thirds of Colebrookdale furnace and iron mines" to his son Thomas, and his "one-third of Pine forge" to his son John. He was of English or Welsh extraction. In 1733 the furnace was torn down and rebuilt by the company, Thomas Potts being the manager. A second Pool forge appears to have been built prior to this time, higher up the stream than the first venture. Mrs. James writes us as follows: "I have a large calf-bound folio ledger of nearly 200 folios of Colebrookdale furnace, marked 'B.' The first date is August, 1728, but there are several pages referring to the first ledger, one of them in 1726. Mention is constantly made of sending 'piggs' to Pool forge, proving that this forge was then in full blast. 'A' would seem to be a large volume from reference to the folios," and therefore to have covered the operations of a number of years. Mrs. James thinks that it is lost. She adds that on the title-page of ledger "B" the name of Thomas Potts is written in connection with the year 1728, probably as the manager or lessee of the furnace. He was a resident of Manatawny in 1725.

On Nicholas Scull's map of Pennsylvania, published in 1759, Colebrookdale furnace is noted, and in a list of iron works existing in Pennsylvania about 1793, and published by Mrs. James, it is again mentioned, although it was not then active. We have not found it mentioned at any later period. A stove-plate cast at this furnace in 1763 was exhibited at the Philadelphia Exhibition of 1876. In 1731 pig iron sold at Colebrookdale furnace "in large quantities" at £5 10s. per ton, Pennsylvania currency, a pound being equal to $\$2.66\frac{2}{3}$. It would seem that friendly Indians were employed at Colebrookdale, as "Indian John" and "Margalitha" are found in the list of workmen about 1728. The furnace was located in the heart of one of the richest deposits of magnetic iron ore in the United States. After being neglected for a long time this deposit is now the centre of great mining activity.

Durham furnace, on the Delaware river, in the extreme northern part of Bucks county, was built in 1727 by a company of fourteen persons, of which Anthony Morris, William Allen, Joseph Turner, and James Logan (Penn's secretary) were members. Its first blast took place in the spring of 1728, and in November of that year James Logan shipped three tons of Durham pig iron to England. At the Philadelphia Exhibition of 1876 the keystone of Durham furnace, bearing date "1727," was an object of interest.

It is probable that about 1750 there were two Durham furnaces. On Nicholas Scull's map of Pennsylvania (1759) an old and a new furnace and a forge at Durham are distinctly marked. In 1770 there were two furnaces and two forges at Durham. There were at one time three forges on Durham creek. As late as 1780 negro slaves were employed at Durham, twelve of whom in that year escaped to the British lines. Much of the iron made at Durham was taken to Philadelphia in boats fashioned somewhat like an Indian canoe, and first built at Durham; hence the term afterwards in common use, "Durham boats." There is now a large furnace at Durham.

Redmond Conyngham, quoted by Day in his *Historical Collections of Pennsylvania*, printed in 1843, says that iron works are supposed to have been established in Lancaster county in 1726 by a person named Kurtz, who is said by another authority to have been an Amish Mennonite. In Egle's *History of Pennsylvania* it is stated that Kurtz's works were on Octorara creek, and that it is possible they were in Maryland and not in Lancaster county. Conyngham also says that the enterprising family of Grubbs "commenced operations in 1728," also in Lancaster county. Both history and tradition are silent concerning the nature of these alleged "operations" at that time. We will refer to the Grubb family again.

In 1728 James Logan wrote that "there are four furnaces in blast in the colony." Colebrookdale and Durham were two of these, but the names of the others are in doubt.

The iron industry of Pennsylvania may fairly be said to have been established on a firm foundation at this period. In 1728–'29 the colony exported 274 tons of pig iron to the mother country. The production of a Pennsylvania furnace at this time was about two tons of iron in twenty-four hours.

The manufacture of nails in Pennsylvania commenced at an early day. In 1731 George Megee, nailer, at the corner of Front and Arch streets, Philadelphia, advertised for sale, at wholesale and retail, all sorts of nails of his own manufacture.

The erection of other forges and furnaces proceeded with great rapidity in the Schuylkill valley and in other eastern portions of Pennsylvania after Rutter and other pioneers had shown the way. McCall's forge, afterwards called Glasgow forge, on Manatawny creek, in Montgomery county, a short distance above Pottstown and below Pool forge, was built by George McCall about 1725. Spring forge, on the Manatawny, in Berks county, west of Colebrookdale furnace and about five miles north of Douglassville, was built in 1729, probably by Anthony Morris. These forges, as well as Pool forge, were supplied with iron from Colebrookdale furnace. Green Lane forge, on Perkiomen creek, in Montgomery county, twenty miles north of Norristown, was built in 1733 by Thomas Mayburry. The workmen employed here were at one time chiefly negro slaves. This forge was supplied with pig iron from Durham furnace before 1747. Mount Pleasant furnace, on Perkiomen creek, in Berks county, thirteen miles above Pottstown, was built by Thomas Potts, Jr., in 1738. A forge of the same name was added before 1743. Pine forge, on the Manatawny, in Berks county, about five miles above Pottstown, was built about 1740 by Thomas Potts, Jr. Oley forge, on the Manatawny, in Berks county, was built in 1744 by John Ross, John Yoder, and John Lesher, as we learn from a paper on the early iron works of Berks county, by Morton L. Montgomery, published in volume VIII. of the *Pennsylvania Magazine of History and Biography*. It was finally abandoned about 1870. Spring, Glasgow, Mount Pleasant, and Green Lane forges were in operation down to the middle of the present century. Pine forge was converted into Pine rolling mill in 1845, and upon the site of Glasgow forge there was erected in 1874 and 1876 a rolling mill which is known as the Glasgow iron works.

Samuel Nutt built a furnace called Reading, on French creek, soon after he built Coventry forge. In this enterprise William Branson may have been a partner. Mrs. James says that two furnaces bearing that name were erected, about a mile from each other, the second after the first was abandoned.

The second furnace of this name was built on French creek, about 1736, by Samuel Nutt and William Branson. In the inventory of the estate of Samuel Nutt, which Gilbert Cope, of West Chester, has kindly placed in our hands, mention is made of "a ring round the shaft at the old furnace," and of "one tonn of sow mettle at new furnace." Acrelius, in speaking of the iron ore on French creek, says: "Its discoverer is Mr. Nutt, who afterwards took Mr. Branz into partnership." The reference is to William Branson. This event occurred as early as March 29, 1728, as their names then appear in the Philadelphia *Weekly Mercury* as partners. Acrelius further says: "They both went to England, brought workmen back with them, and continued together." Mrs. James says: "The 15th day of March, 1736, Samuel Nutt and William Branson entered into an agreement with John Potts to carry on their furnace called Redding, recently built near Coventry, and of which they are styled 'joint owners.'" At a meeting of the Provincial Council on January 25, 1737, "a petition of sundry inhabitants of the county of Lancaster was presented to the board and read, setting forth the want of a road from the town of Lancaster to Coventry iron works, on French creek, in Chester county, and praying that proper persons of each of the counties may be appointed for laying out the same from Lancaster town to the said iron works, one branch of which road to goe to the new furnace, called Redding's furnace, now erecting on the said creek." On October 7th of the same year commissioners were appointed to lay out the road.

Samuel Nutt died late in 1737. In his will, dated September 25, 1737, he gave one-half of his "right" to Reading furnace and Coventry forge to his wife, and the other half to Samuel Nutt, Jr., and his wife. He also made provision for the erection of a new furnace by his wife. This furnace was commenced in the same year, and was built on the south branch of French creek. It was probably finished in 1738. In 1740 its management fell into the hands of Robert Grace, (a friend of Benjamin Franklin,) who had recently married the widow of Samuel Nutt, Jr. This lady was the granddaughter of Thomas Rutter. The new furnace was called Warwick. The celebrated Franklin stove was invented by Benjamin Franklin in 1742, and in his autobiography he

says: "I made a present of the model to Mr. Robert Grace, one of my early friends, who, having an iron furnace, found the casting of the plates for these stoves a profitable thing, as they were growing in demand." Mrs. James has seen one of these stoves, with the words "Warwick Furnace" cast on the front in letters two inches long. Bishop says that Warwick furnace "was blown by long wooden bellows propelled by water wheels, and when in blast made 25 or 30 tons of iron per week." It continued in operation during a part of almost every year from its erection in 1738 down to 1867, when its last blast came to an end and the furnace was abandoned. During the Revolution it was very active in casting cannon for the Continental army, some of which were buried upon the approach of the British in 1777, and have only recently been recovered, having lain undisturbed for a hundred years. The lower part of the stack of Warwick furnace to a point above the boshes still remains.

After Samuel Nutt's death Reading furnace became the property of his partner, William Branson. It is noted on Nicholas Scull's map of 1759. Coventry forge finally fell to Samuel Nutt's heirs. The German traveler, Schoepf, writing in 1783 of some Pennsylvania furnaces and forges, makes the following mention of Warwick and Reading furnaces: "Warwick furnace, 19 miles from Reading, near Pottsgrove, makes the most iron, often 40 tons a week; the iron ore lies 10 feet under the surface. Reading furnace, not far from the former, is at present fallen into decay. Here the smelting would formerly often continue from 12 to 18 months at a stretch."

At an uncertain period about 1750 William Branson and others established on French creek the Vincent steel works. They are thus described by Acrelius: "At French creek, or Branz's works, there is a steel furnace, built with a draught hole, and called an 'air oven.' In this iron bars are set at the distance of an inch apart. Between them are scattered horn, coal-dust, ashes, etc. The iron bars are thus covered with blisters, and this is called 'blister steel.' It serves as the best steel to put upon edge tools. These steel works are now said to be out of operation." Vincent forge, with four fires and two hammers, was connected with Vincent steel furnace, but the date of its erection is also uncertain. It is noted

on William Scull's map of 1770. The furnace and forge were located about six miles from the mouth of French creek, and about five miles distant from Coventry forge, which was farther up the stream. Before February 15, 1797, a rolling and slitting mill had been added to the forge. We do not hear of the steel furnace after 1780, nor of the forge after 1800.

In 1742 William Branson, then owner of Reading furnace, bought from John Jenkins a tract of 400 acres of land on Conestoga creek, near Churchtown, in Caernarvon township, Lancaster county, on which he soon afterwards erected two forges, called Windsor. In a short time, as we are informed by Mr. James McCaa, "Branson sold out to the English company, who were Lynford Lardner, Samuel Flower, and Richard Hockley, Esqs., who held it [Windsor] for thirty years, when, in 1773, David Jenkins, son of the original proprietor, bought the half interest of the company for the sum of £2,500, and in two years afterwards bought the other half for the sum of £2,400, including the negroes and stock used on the premises." Robert Jenkins inherited the Windsor forges from his father David, and managed them with great success for fifty years, dying in 1848. They have since been abandoned.

David Jenkins was a member of the legislature in 1784. Robert Jenkins was a member of the legislature in 1804 and 1805, and from 1807 to 1811 he was a member of Congress.

Acrelius, narrating events which occurred between 1750 and 1756, mentions the enterprises of Nutt and Branson as follows: "Each has his own furnace—Branz at Reading, Nutt at Warwick. Each also has his own forges—Branz in Windsor. Nutt supplies four forges besides his own in Chester county." Nutt was not living at the time this was written, but Acrelius's confounding of ownership is easily understood. Nor is it probable that Branson operated Windsor forges in 1750. In that year he is reported as having then owned a furnace for making steel in Philadelphia, and about 1743 it is known that he sold Windsor forges to the "English company," which was composed of his sons-in-law. William Branson was himself an Englishman, who emigrated to Pennsylvania about 1708 and became a Philadelphia merchant. He died in 1760.

Continuing in the Schuylkill valley, we find in 1751 a

forge, called Mount Joy, at the mouth of East Valley creek, on the Chester county side of the creek, the one-third of which was advertised for sale on the 4th of April of that year by Daniel Walker, and the remaining two-thirds on the 26th of September of the same year by Stephen Evans and Joseph Williams. In Daniel Walker's advertisement it was stated that the forge was "not so far distant from three furnaces." Pennypacker, in his *Annals of Phœnixville and its Vicinity*, says that "the ancestor of the Walker family" had come from England with William Penn, and "at a very early date had erected the small forge on the Valley creek." It is clear, however, that in 1751 Daniel Walker owned only the one-third of the forge, Evans and Williams owning the remainder. In 1757, as we learn from Mrs. James, the forge was sold to John Potts by the executors of Stephen Evans. In 1773 it was owned by Joseph Potts, at which time it continued to be legally designated as Mount Joy forge, although for some time previously it had been popularly known as Valley forge. In that year Joseph Potts sold one-half of the forge to Colonel William Dewees. The pig iron used at Valley forge was hauled from Warwick furnace. In September, 1777, the forge was burned by the British, and in December of the same year the Continental army under Washington was intrenched on the Montgomery county side of Valley creek, opposite to Valley forge. General Washington's headquarters were established at the substantial stone house of Isaac Potts, also on the Montgomery county side of Valley creek. This house is still standing. Isaac Potts was not, however, at this time an owner of Valley forge. After the close of the Revolutionary war Isaac and David Potts, brothers, erected another forge, on the Montgomery county side of Valley creek, and about three-eighths of a mile below the old Mount Joy forge. A new dam was built, which raised the water partly over the site of the old forge. About the same time, and as early as 1786, a slitting mill was built on the Chester county side of the stream by the same persons. The new forge was called Valley forge. It was in ruins in 1816. Other iron enterprises, of a reproductive character, were established at the town of Valley Forge early in the present century, and about 1818 cast steel to be used in the manufacture of saws was made here.

About 1824 all of the iron works at Valley Forge were discontinued. The manufacture of steel had previously been abandoned.

William Bird was an enterprising Englishman who established several iron enterprises in Berks county before the Revolution. A person of this name was a witness of Thomas Rutter's will, on November 27, 1728, when he appears to have been a resident of Amity township, Berks county. In 1740 or 1741 William Bird built a forge on Hay creek, near its entrance into the Schuylkill, where Birdsboro now stands. Hopewell furnace, on French creek, in Union township, which is still in operation and still using charcoal, is said by tradition to have been built by William Bird in 1759, but it may have been built by his son, Mark Bird, about 1765. As early as 1760 William Bird built Roxborough furnace, in Heidelberg township, the name of which furnace was subsequently changed to Berkshire. Dying in 1762, his estate was divided between his widow and his six children. Berkshire furnace fell to his son, Mark Bird, who sold it in 1764 to John Patton and his wife Bridget, who had been the wife of William Bird. In 1789 Bridget Patton, again a widow, sold the furnace to George Ege, who abandoned it about 1794, in which year he built Reading furnace, on Spring creek, in Heidelberg township. On its site the two Robesonia furnaces were afterwards built. Berkshire furnace manufactured shot and shells for the Continental army. Mark Bird built a rolling and slitting mill and a nail factory at Birdsboro about the time of the Revolution. At Trenton, New Jersey, he manufactured wire. He failed in business about 1788.

Charming forge, on Tulpehocken creek, in Berks county, was built in 1749 by John George Nikoll, a hammersmith, and Michael Miller. It was at first styled *Tulpehocken Eisen Hammer*. This forge is still in operation. Mr. Montgomery says that it was owned in 1763 by Henry William Stiegel, and that in 1774 it was purchased by George Ege. About 1777 Mr. Ege purchased from Congress the services of thirty-four Hessian prisoners, for the purpose of cutting a channel through a bed of rock to supply with water-power a slitting mill which he had previously erected. W. & B. F. Taylor, the present owners of the forge, write us that the race is still

used, that it is about 100 yards long, from 12 to 20 feet deep, and about 20 feet wide, and that it was cut through a mass of solid slate rock as smoothly as if done with a broad-axe.

George Ege was for almost fifty years one of the most prominent ironmasters in Pennsylvania. His possessions in Berks county were at one time princely. He died in December, 1830. He was a native of Holland.

On William Scull's map of 1770 Moselem forge, on Maiden creek, Berks county, and Gulf forge, on Gulf creek, in Upper Merion township, Montgomery county, are noted. Helmstead, Union, and Pottsgrove were the names of other forges existing in 1750 in the Schuylkill valley.

Oley furnace, on Furnace creek, a branch of Manatawny creek, about eleven miles northeast of Reading, was built about 1765, probably by Dietrich Welcker, as we learn from Mr. Montgomery. It is still in operation.

There was a forge on Crum creek, about two miles above the town of Chester, in Delaware county, which was built by John Crosby and Peter Dicks about 1742. Peter Kalm, the Swede, in his *Travels into North America*, written in 1748 and 1749, thus describes it: "About two English miles behind Chester I passed by an iron forge, which was to the right hand by the road side. It belonged to two brothers, as I was told. The ore, however, is not dug here, but thirty or forty miles from hence, where it is first melted in the oven, and then carried to this place. The bellows were made of leather, and both they and the hammers, and even the hearth, [were] but small in proportion to ours. All the machines were worked by water. The iron was wrought into bars." The "oven" here referred to was a blast furnace, which was probably located in the Schuylkill valley, the pigs for the forge being boated down the Schuylkill and the Delaware and up Crum creek. Acrelius says that the forge was owned at the time of his visit by Peter Dicks, and that it had two stacks, was worked sluggishly, and had "ruined Crosby's family."

As early as 1742 John Taylor built a forge on Chester creek, in Thornbury township, Delaware county, where Glen Mills now stand, which he called Sarum iron works. In 1746 he added a rolling and slitting mill. These works are said to have been carried on with energy by Mr. Taylor until his

death in 1756. Acrelius, writing about the time of Mr. Taylor's death, says: "Sarum belongs to Taylor's heirs; has three stacks, and is in full blast." Peter Kalm states that at Chichester (Marcus Hook) "they build here every year a number of small ships for sale, and from an iron work which lies higher up in the country they carry iron bars to this place and ship them." This iron work was probably Sarum. Taylor's rolling and slitting mill was the first in Pennsylvania.

John Taylor was descended from a family of the same name in Wiltshire, England, and was a nephew of Jacob Taylor, who was surveyor-general of Pennsylvania from 1707 to 1733. His business operations were upon an extensive and varied scale, and included the manufacture of nails as well as nail rods. The tradition is preserved by his descendants that soon after the erection of the slitting mill his storekeeper, in making one of his periodical visits to England, to replenish his stock, surprised the Liverpool merchants by telling them that he could buy nails at Taylor's mill at lower prices than they quoted—a revelation which added weight to the clamor then prevailing in England for the suppression of slitting mills and similar iron establishments in America, and which agitation resulted in the passage in 1750 of an act of Parliament which prohibited the further erection of such works. But, as this act did not prohibit the carrying on of works that had already been erected, Taylor's slitting mill was kept in operation after his death, first by his son John and afterwards by the latter's son-in-law, Colonel Persifor Frazer. During the Revolution the superintendence of the estate, including the management of the iron works, devolved upon Mrs. Frazer. The works were abandoned soon after the war, owing in part to the industrial depression which then prevailed.

In 1750 there was a "plating forge with a tilt-hammer" in Byberry township, in the northeastern part of Philadelphia county, (the only one in the province,) owned by John Hall, but not in use in that year. In the same year there were two steel furnaces in Philadelphia, one of which, Stephen Paschall's, was built in 1747, and stood on a lot on the northwest corner of Eighth and Walnut streets; the other furnace was owned by William Branson, and was located near where Thomas Penn "first lived, at the upper end of Chest-

nut street." These furnaces were for the production of blister steel. There appear to have been no other steel furnaces in the province in 1750. Whitehead Humphreys was in 1770 the proprietor of a steel furnace on Seventh street, between Market and Chestnut streets, in Philadelphia, where he also made edge tools. In February, 1775, Uriah Woolman and B. Shoemaker, "in Market street, Philadelphia," advertised in Dunlap's *Pennsylvania Packet* "Pennsylvania steel, manufactured by W. Humphreys, of an excellent quality, and warranted equal to English, to be sold in blister, faggot, or flat bar, suitable for carriage springs." We have already referred to the Vincent steel works in Chester county.

Elizabeth furnace, near Brickersville, in Lancaster county, on Middle creek, a branch of Conestoga creek, was built about 1750 by John Huber, a Pennsylvania German. It was a small furnace, and did not prove to be profitable. In 1757 Huber sold it to Henry William Stiegel and his partners, who built a new and larger furnace, which was operated until 1775, when, through Stiegel's embarrassments, it passed into the hands of Daniel Benezet, who leased it to Robert Coleman, who subsequently bought it and eventually became the most prominent ironmaster in Pennsylvania at the close of the last century and far into the present century. Bishop states that "some of the first stoves cast in this country were made by Baron Stiegel, relics of which still remain in the old families of Lancaster and Lebanon counties." Rev. Joseph Henry Dubbs, of Lancaster, says that Stiegel's stoves bore the inscription:

Baron Stiegel ist der Mann
Der die Ofen machen kann.

That is, "Baron Stiegel is the man who knows how to make stoves." On the furnace erected by Huber the following legend was inscribed:

Johann Huber, der erste Deutsche Mann
Der das Eisenwerk vollführen kann.

Freely translated this inscription reads: "John Huber is the first German who knows how to make iron."

We have already referred to Stiegel's ownership of Charming forge in 1763. In that year he sold a half interest in it to Charles and Alexander Stedman, of Philadelphia, and

in 1773 the sheriff sold his remaining interest. Soon after 1760 he established a glass factory at Manheim, in Lancaster county, called the American flint-glass factory, which was in operation as late as 1774. He was a native of Germany, arriving in this country on August 31, 1750, (old style,) in the ship *Nancy*, from Rotterdam. He is buried in the Lutheran graveyard near Womelsdorf, in Heidelberg township, Berks county. In his last days he taught school in this township.

After Elizabeth furnace came into the possession of Robert Coleman he cast shot and shells and cannon for the Continental army, and some of the transactions which occurred between him and the Government in settlement of his accounts for these supplies are very interesting. On November 16, 1782, appears the following entry: "By cash, being the value of 42 German prisoners of war, at £30 each, £1,260;" and on June 14, 1783, the following: "By cash, being the value of 28 German prisoners of war, at £30 each, £840." In a foot note to these credits Robert Coleman certifies "on honour" that the above 70 prisoners were all that were ever secured by him, one of whom being returned is to be deducted when he produces the proper voucher. Rupp, in his history of Lancaster county, mentions that in 1843 he visited one of the Hessian mercenaries who was disposed of in this manner at the close of the war for the sum of £80, for the term of three years, to Captain Jacob Zimmerman of that county.

Elizabeth furnace continued in operation until 1856, when it was abandoned by its owner, Hon. G. Dawson Coleman, the grandson of Robert Coleman, for want of wood.

Among the persons who were employed at Windsor forges under the "English company" was James Old, a forgeman. About 1765 he built Pool forge, on Conestoga creek, about a mile below Windsor forges. Early records mention his ownership of Quitapahilla forge, near Lebanon, and other forges in Chester, Lancaster, and Berks counties. In 1773 he was a lessee of Reading furnace, on French creek. In 1795 he conveyed Pool forge and about 700 acres of land attached to it to his son, Davies Old.

James Old was born in Wales in 1730. He emigrated to Pennsylvania previous to September 7, 1754, when his name for the first time appears in the register of Bangor church, at

Churchtown, Lancaster county, as the contributor of £5 toward the erection of the church building. Soon after his settlement at Windsor he married Margaretta Davies, a daughter of Gabriel Davies, of Lancaster county. Gabriel Davies is supposed to have been the owner of the site on which Pool forge was built. James Old died on May 1, 1809, in his 79th year, and is buried in the graveyard of Bangor church. He was one of the most enterprising and successful of early Pennsylvania ironmasters. He had a brother William, also a forgeman, who had been employed at Windsor forges, and who is said to have embarked in the manufacture of bar iron on his own account. James Old was a member of the legislature in 1791, 1792, and 1793.

William Old, a son of James Old, married Elizabeth Stiegel, the daughter of Baron Stiegel. She is buried in the same rural graveyard which holds the remains of her father. Mrs. Henry Morris, of Philadelphia, is her grand-daughter.

Robert Coleman was in his younger days in the service of James Old, and while with him at Reading furnace in 1773 he married his daughter Ann. Soon after his marriage he rented Salford forge, above Norristown, in Montgomery county, where he remained three years. While at this forge he manufactured chain bars, which were used to span the Delaware river for the defense of Philadelphia against the approach of the British fleet. From Salford forge he went to Elizabeth furnace. He was born near Castle Fin, in Donegal county, and not far from the city of Londonderry, in Ireland, on the 4th of November, 1748. In 1764, when 16 years old, he left Ireland for America. He died at Lancaster in 1825, at which place he is buried. He was an officer in the Pennsylvania militia during the Revolution, a member of the State convention which framed the Constitution of 1790, a member of the legislature, raised and commanded a troop of cavalry during the whisky insurrection, was a Presidential elector-at-large in 1792 and a Presidential elector for his Congressional district in 1796, and for nearly twenty years was an associate judge of Lancaster county.

Cyrus Jacobs married Margaretta, another daughter of James Old, about 1782. At that time Mr. Jacobs was living at Churchtown, in the employment of James Old as a clerk

at Pool forge. He was at Gibraltar forge, in Berks county, in 1787, and at Hopewell forge, in Lancaster county, from 1789 to 1792. In 1793 he built Spring Grove forge, on Conestoga creek, about three miles west of Pool forge, and in 1799 he purchased Pool forge from Davies Old. Pool forge was active until 1861 or 1862, and Spring Grove forge until 1866, after which years they were respectively abandoned. Cyrus Jacobs was born in 1761, and died in 1830 at Whitehall, near Churchtown. He is buried in the graveyard of Bangor church.

Cornwall furnace, located within the limits of the now celebrated Cornwall ore hills, on Furnace creek, in Lebanon county, a few miles south of Lebanon, was built in 1742 by Peter Grubb, whose descendants to this day have been prominent Pennsylvania ironmasters. He was the son of John Grubb, a native of Cornwall, in England, who emigrated to this country late in the preceding century, landing at Grubb's Landing, on the Delaware, near Wilmington, at which latter place he is buried. There is record evidence that Peter Grubb was already an ironmaster before he built Cornwall furnace, and a tradition in his family says that in 1735 he built a furnace or bloomary, most likely the latter, about five-eighths of a mile from the site of Cornwall furnace. He died intestate about 1754, and his estate, including the Cornwall ore hills, descended to his two sons, Curtis and Peter Grubb, both of whom were afterwards colonels during the Revolution.

A few years after the death of Peter Grubb Acrelius wrote of Cornwall furnace as follows: "Cornwall, or Grubb's iron works, in Lancaster county. The mine is rich and abundant, forty feet deep, commencing two feet under the earth's surface. The ore is somewhat mixed with sulphur and copper. Peter Grubb was its discoverer. Here there is a furnace which makes twenty-four tons of iron a week, and keeps six forges regularly at work—two of his own, two belonging to Germans in the neighborhood, and two in Maryland. The pig iron is carried to the Susquehanna river, thence to Maryland, and finally to England. The bar iron is sold mostly in the country and in the interior towns; the remainder in Philadelphia. It belongs to the heirs of the Grubb estate, but is now rented to Gurrit & Co." This firm was doubtless Garret & Co.

During the Revolution Cornwall furnace cast cannon and

shot and shells for the Continental army. It is still in operation, and is the oldest active charcoal furnace in the United States. It has always used charcoal.

In 1785 Robert Coleman purchased a one-sixth interest in Cornwall furnace and the ore hills. After that year, through successive purchases from the Grubbs, he obtained four additional sixths of the Cornwall property. His total purchases of this valuable property remain in the hands of his descendants at this day.

Martic forge, on Pequea creek, near the present village of Colemanville, Lancaster county, was built in 1755, and is still in operation. Early in this century cemented or blister steel was made here. Mr. R. S. Potts, one of the present owners of Martic forge, writes us as follows: "There used to be a small rolling mill near the forge that stopped running some fifty years ago. There was also a charcoal furnace called Martic some six miles east of the forge, but I have been unable to ascertain its history beyond the fact that it was owned and operated by the Martic Forge Company; when that was, however, or how long it was in blast, I can not learn. The old cinder bank is still visible. During the Revolution round iron was drawn under the hammer at the forge and bored out for musket barrels at a boring mill, in a very retired spot, on a small stream far off from any public road, doubtless with a view to prevent discovery by the enemy. The site is still visible." In 1769 Martic furnace and forge were advertised for sale by the sheriff, together with 3,400 acres of land and other property, "all late the property of Thomas Smith, James Wallace, and James Fulton." The furnace was in existence about 1793, but it was not then active.

Hopewell forge, on Hammer creek, in Lancaster county, about ten miles south of Lebanon, was built by Peter Grubb soon after he built Cornwall furnace. Speedwell forge, on the same stream, near Brickersville, in Lancaster county, was built about 1750, also by Peter Grubb.

The iron industry of Pennsylvania crossed the Susquehanna at a very early period. Acrelius says that there was a bloomary in York county in 1756, owned by Peter Dicks, who had but recently discovered "the mine." Spring forge, on Codorus creek, in the same county, was built in 1770, and was in

operation in 1849, but was abandoned about 1850. At first it was probably only a bloomary. Soon after 1762 a furnace and forge were built at Boiling Springs, in Cumberland county, forming the nucleus of the Carlisle iron works, which afterwards embraced a blast furnace, a rolling and slitting mill, and a steel furnace. Mr. C. W. Ahl writes us that the furnace and forge were built soon after 1762 by a company composed of Amos Stuttle, Samuel Morris, Joseph Morris, John Morris, and John Armstrong, all of Philadelphia. The site of these enterprises, with some contiguous territory, it purchased from John Rigby and Nathan Giles. Michael Ege owned them after 1782. On a tax list at Carlisle Robert Thornburg & Co. appear as the owners of a forge in 1767 to which 1,200 acres of land were attached. We can not locate this forge. A forge is supposed to have been built at Mount Holly in 1765. Pine Grove furnace, in the same county, was built about 1770 by Thornburg & Arthur. In 1782 Michael Ege became a part owner of the furnace and subsequently sole owner. A forge called Laurel was attached to this furnace. Both the furnace and forge are still in operation. No other iron works west of the Susquehanna are known to have been established previous to the Revolution.

CHAPTER XII.

CHARACTERISTICS OF THE EARLY IRON INDUSTRY OF PENNSYLVANIA.

ALTHOUGH all the iron enterprises that were established in Pennsylvania prior to the Revolution have not been mentioned in the preceding pages, those which have been mentioned indicate remarkable activity in the development of the iron resources of the province. Pennsylvania was one of the last of the thirteen colonies to be occupied by permanent English settlements, and even after these settlements were made a long time elapsed, very strangely, before the erection of iron works was successfully undertaken. The manufacture of iron was not fairly commenced in Pennsylvania until 1716, but after this time it grew rapidly, and in the sixty years which intervened before the commencement of hostilities with the mother country probably sixty blast furnaces and forges were built—a rate of progress which was not attained by any other colony in the same period. Acrelius said in 1759: "Pennsylvania, in regard to its iron works, is the most advanced of all the American colonies." Many of these enterprises were upon a scale that would have done credit to a much later period of the American iron industry. Cornwall and Warwick furnaces were each 32 feet high, 21½ feet square at the base, and 11 feet square at the top. Warwick was at first 9 feet wide at the boshes, but was afterwards reduced to 7½ feet. The forges were usually those in which pig iron was refined into bar iron "in the Walloon style," as stated by Acrelius. There were few ore bloomaries, and nearly all of these were built at an early day. Acrelius mentions only one of this class—Peter Dicks' bloomary, in York county. The smaller furnaces yielded only from 1½ to 2 tons of pig iron daily, but the larger ones yielded from 3 to 4 tons. Reading, Warwick, and Cornwall furnaces each made from 25 to 30 tons of iron per week. The furnaces were required to produce both pig iron and castings, the latter consisting of stoves, pots, kettles, andirons, and similar articles. Of the product of the forges Acrelius says that "one

forge, with three hearths in good condition, and well attended to, is expected to give 2 tons a week." The same writer says that "for four months in summer, when the heat is most oppressive, all labor is suspended at the furnaces and forges." The scarcity of water at this season would also have much to do with this suspension, all of the works being operated by water-power. At first large leather bellows were used exclusively to blow both the forges and the furnaces, but afterwards, about the time of the Revolution, wooden cylinders, or "tubs," were also used. It was not until after the beginning of the present century that steam-power was experimentally used to produce the blast at either furnaces or forges in Pennsylvania, or in any other State. Warwick and Cornwall furnaces, two of the best furnaces of the last century, retained their long leather bellows until the present century. Reading furnace, the neighbor of Warwick, and also a rival of both Warwick and Cornwall, was blown with leather bellows. The Cornwall bellows was 20 feet 7 inches long, 5 feet 10 inches wide across the breech, and 14 inches wide at the insertion of the nozzle. Only one tuyere was used. The fuel used was exclusively charcoal, and the blast was always cold. Schoepf says that about 400 bushels of charcoal were required to produce from the ore a ton of hammered bar iron. He also says that mahogany was used to make the moulds for the castings at the furnaces, "because it warps and cracks the least."

The following notice of the workmen employed in making iron in Pennsylvania prior to the Revolution, and of the prices of iron in the same period, is taken from Acrelius's *History of New Sweden*, printed in 1759, but covering the period of his visit from 1750 to 1756.

The workmen are partly English and partly Irish, with some few Germans, though the work is carried on after the English method. The pig-iron is smelted into "geese," ("gœsar,") and is cast from five to six feet long and a half foot broad, for convenience of forging, which is in the Walloon style. The pigs are first operated upon by the finers, (smelters). Then the chiffery, or hammer-men, take it back again into their hands, and beat out the long bars. The finers are paid 30s. a ton and the hammer-men 23s. 9d. per ton; that is to say, both together, £2 13s. 9d. The laborers are generally composed partly of negroes, (slaves,) partly of servants from Germany or Ireland bought for a term of years. A good negro is bought for from £30 to £40 sterling, which is equal to 1,500 or 2,000 of our dollars, koppar mynt.

Their clothing may amount to 75 dollars, koppar mynt, their food, 325 ditto —very little, indeed, for the year. The negroes are better treated in Pennsylvania than anywhere else in America. A white servant costs 350 dollars, koppar mynt, and his food is estimated at 325 dollars more, of the same coinage. For four months, in summer, when the heat is most oppressive, all labor is suspended at the furnaces and forges. Pig-iron is sold at the furnaces for from £3 6s. 8d. to £3 10s. per ton. Bar-iron at the forge brings £20 per ton, or 20s. per 100 pounds. It is sold dear, for six months credit is given. Pig-iron is sold in Philadelphia at £5 per ton; bar-iron, in large quantities, at from £14 to £16 per ton. It certainly seems remarkable that the price is diminished after the long transportation to the city; but in this people find their profit.

The iron-works of Pennsylvania lie mostly within forty miles of Philadelphia. The carriage for such a distance does not exceed twenty shillings sterling per ton. As a set-off to this is reckoned the return-freight upon goods serviceable for the storehouse of the works.

The sheriff's advertisement for the sale of Martic furnace and forge, in 1769, already referred to, and which we give below, indicates very correctly the extent and character of a representative Pennsylvania iron enterprise before the Revolution.

By virtue of a writ to me directed, will be exposed to sale, by public vendue, on the 30th day of January inst., at 10 o'clock in the morning, at Martick Furnace, in Lancaster county, the said furnace and forge, together with upwards of 3,400 acres of land, thereunto belonging. The improvements at both furnace and forge are very good, viz.: At the furnace, a good dwelling-house, stores, and compting-house, a large coal-house, with eight dwelling-houses for the labourers, a good grist-mill, Smith's and Carpenter's shops, 6 good log stables, with 4 bays for hay, a number of pot patterns, and some flasks for ditto, stove moulds, &c., &c.; a good mine bank, abounding with plenty of ore, so convenient that one team can haul three loads a day; about 15 acres of good watered meadow, and as much adjoining may be made: The Forge is about 4 miles distant, now in good order, with four fires, two hammers, and very good wooden bellows, a dwelling-house, store, and compting-house, with six dwelling-houses for the labourers, two very good coal-houses, large enough to contain six months' stock, three stables, Smith's and Carpenter's shops, two acres of meadow made, and about 1,500 cords of wood, cut in the woods at both places; there is plenty of water at said works in the driest season, and they are situated in a plentiful part of the country, where they can be supplied with necessaries on the lowest terms: And to be sold the same day, a very good plantation, containing 200 acres of patent land, clear of quitrent, adjoining the lands of Benjamin Ashleman, the Widow Haiman, and others, in Conestogo township. Also two slaves, one a Mulattoe man, a good forge man, the other a Negro man, and three teams of horses, with waggons and gears, &c. All late the property of Thomas Smith, James Wallace, and James Fulton; seized and taken in execution, and to be sold by JAMES WEBB, *Sheriff*.

CHAPTER XIII.

THE MANUFACTURE OF CHARCOAL IRON IN EASTERN PENNSYLVANIA AFTER THE REVOLUTION.

AFTER the Revolution the business of manufacturing iron received a fresh impulse in the eastern part of Pennsylvania, and was further extended into the interior. Chester, Lancaster, and Berks counties shared conspicuously in the development at this period of the leading manufacturing industry of the State. Many blast furnaces and forges and a few rolling and slitting mills were built in these counties before 1800, and after the beginning of the present century this activity continued. A few of the earliest charcoal iron enterprises that were established after the Revolution in these and in other eastern and central counties may be mentioned.

In 1790 Benjamin Longstreth erected a rolling and slitting mill at Phœnixville, in Chester county, where the foundry now stands. This was the beginning of the present extensive works of the Phœnix Iron Company.

Clemens Rentgen, a native of the Palatinate, (now Bavaria,) in Germany, emigrated from the town of Zweibrücken in 1791 to Kimberton, in Chester county, about six miles from Phœnixville, where he purchased a forge on French creek. At Knauertown he unsuccessfully undertook to manufacture steel. His forge was continued, and to it he added a small rolling mill. His various enterprises were known as the Pikeland works, Pikeland being the name of the township in which they were situated.

On November 17, 1796, Mr. Rentgen obtained a patent for an invention for "forging bolts or round iron" by a machine which he described in the following words: "This machine consists of a strong platform, of a given size, in which are fixed two upright posts. In these posts is fixed an axle going through the handle of a concave hammer or sledge, at the extreme end of which is fixed a cog-wheel, whose cogs, operating on the lever or handle of the said concave hammer or sledge, cause it to operate upon a concave anvil upon which

the iron to be wrought is placed. The concavity of this anvil is about one-eighth of the dimensions of that of the said hammer or sledge. This machine is set in motion by water or any other adequate power, by wheels operating upon the said cog-wheel."

On June 27, 1810, Mr. Rentgen obtained a patent for "rolling iron round, for ship bolts and other uses," by the following method: "This machine consists of two large iron rollers, fixed in a strong frame. Each roller has concavities turned in them, meeting each other to form perfect round holes, of from half inch to one and three-quarter inches or any other size in diameter, through which rollers the iron is drawn from the mouth of the furnace with great dispatch, and the iron is then manufactured better and more even than it is possible to forge it out. The force applied to the end of these rollers is like that applied to mills."

The original patents granted to Mr. Rentgen have been shown to us by his descendant, Professor William H. Wahl, of Philadelphia. We learn from this gentleman that Mr. Rentgen made some use of his patent anvil and hammer, and that, before obtaining the patent in 1810 for his method of rolling round iron, he built an experimental set of rolls, which were replaced after the patent was granted by a permanent set, with which he rolled round iron as early as 1812 or 1813, some of which was for the Navy Department of the United States Government. We do not learn that he ever rolled bar iron, and it is not claimed that he used puddling furnaces. The fact that a patent was granted to him as late as June 27, 1810, for a machine to roll iron in round shapes, would seem to furnish conclusive proof that Cort's rolls had not then been introduced into the United States.

Federal slitting mill, on Buck run, about four miles south of Coatesville, in East Fallowfield township, Chester county, was built in 1795 by Isaac Pennock. The name of this mill was afterwards changed to Rokeby rolling mill. It was used to roll sheet iron and nail plates and to slit the latter into nail rods. It continued in operation until 1864, when it was burned down and abandoned. During the latter part of its history it rolled boiler plates. A paper mill now occupies its exact site. About 1810 Mr. Pennock built Brandywine rolling

mill at Coatesville, which was purchased from him about 1816 by Dr. Charles Lukens, who had been employed at the Federal slitting mill. It is claimed that the first boiler plates made in the United States were rolled at this mill by Dr. Lukens. The puddling mill of the Lukens rolling mill at Coatesville now occupies the site of the Brandywine mill. Upon the death, in 1825, of Dr. Lukens, who had become the owner of the Brandywine mill, the management of the mill devolved upon his wife, Rebecca W. Lukens, by whom the business was greatly extended and profitably conducted for twenty years. After her death the name of the works was changed to Lukens rolling mill, as a tribute to her memory.

Mount Hope furnace, located on Big Chiquisalunga creek, in Lancaster county, about ten miles south of Lebanon, was built in 1785 by Peter Grubb, Jr., and it is still operated by members of the Grubb family. Colebrook furnace, on the Conewago, in Lebanon county, seven miles southwest of Cornwall furnace, was built by Robert Coleman in 1791 and abandoned about 1860. Mount Vernon furnace, on the same stream, about twenty-three miles west of Lancaster, and in Lancaster county, was built in 1808 by Henry Bates Grubb. A second furnace of the same name was built near the first in 1831. Both have been abandoned. Conowingo furnace, on the creek of the same name, and about sixteen miles southeast of Lancaster, was built in 1809. About 1840 steam-power for driving the blast was successfully introduced by its owner, James M. Hopkins, the boilers being placed at the tunnel-head. Soon after the introduction of steam at Conowingo furnace it was successfully applied to Cornwall furnace by the manager, Samuel M. Reynolds.

In 1786 there were seventeen furnaces, forges, and slitting mills within thirty-nine miles of Lancaster. In 1838 there were 102 furnaces, forges, and rolling mills within a radius of fifty-two miles of Lancaster. At this time Lancaster was the great iron centre of Eastern Pennsylvania.

In 1805 there were seven forges and one slitting mill in Delaware county. Franklin rolling mill, at Chester, in this county, was built in 1808. In 1828 there were in Delaware county five rolling and slitting mills and several manufactories of finished iron products.

In 1798 there were six furnaces and six forges in Berks county; in 1806 there were eight furnaces, twenty forges, and one slitting mill; and in 1830 there were eleven furnaces and twenty-four forges.

The Cheltenham rolling mill, on Tacony creek, in Montgomery county, one mile below Shoemakertown, was built in 1790, probably by James Rowland and Maxwell Rowland. In 1856 it was owned and operated by Rowland & Hunt, making boiler plates from blooms. It was abandoned in 1858. At first this mill was used to slit nail rods. The firm of Rowland & Hunt was composed of Mrs. Harriet Rowland, a widow, and Mr. Alfred Hunt.

The first iron enterprises in the Lehigh valley, which is now one of the leading iron districts of the country, do not appear to have been undertaken until after the beginning of the present century. A bloomary at or near Jacobsburg, in Northampton county, is said to have been built in 1805. It was in operation as late as 1849. In 1808 William Henry, of Nazareth, built a bloomary in Bushkill township, Northampton county, about three miles north of Nazareth, which was started in 1809, making its first bar of iron on the 9th of March in that year. In 1824 Matthew S. Henry, a son of William Henry, built a furnace called Catharine, in Bushkill township, about half a mile from his father's bloomary. It made its first ton of pig iron on the 10th of May, 1825.

Hampton furnace, near Shimersville, in Lehigh county, was built in 1809 by David Heimbach and two partners named Wisselman and Cobelly. Mr. Heimbach soon purchased the interest of his partners and continued to operate the furnace until 1830, after which it was owned and operated by various persons. It was in blast as late as 1857. In 1820 David Heimbach and his son David built Clarissa forge, on Aquashicola creek, in Carbon county. In 1827 David Heimbach the younger built Clarissa furnace at the same place, which he operated until his death in 1834. In 1837 the furnace and forge were both purchased by Joseph J. Albright, Samuel P. Templeton, and Jacob Rice, by whom their name was changed to the Ashland iron works. In 1841 the furnace and forge were both swept away by a freshet. The furnace was not rebuilt, but the forge was rebuilt, burned down, again

rebuilt, and finally abandoned about 1860. On April 14, 1826, David Heimbach the elder purchased 129 acres of land on Pocopoco creek, near Weissport, in Carbon county, and on this tract he built in 1827 a furnace and forge, which he called New Hampton. The name of this furnace and forge was changed to Maria in 1836 by William Miller, who purchased them in that year. The furnace was finally blown out in 1859.

In 1826 Stephen Balliet and Samuel Helfrick built Lehigh furnace, on Trout creek, at the foot of the Kittatinny mountains, in Heidelberg (now Washington) township, in Lehigh county. It was a small furnace, 30 feet high and 7 feet wide at the boshes. The furnace was operated by this firm until the death of Mr. Helfrick in 1830. In 1832 Mr. Balliet became its sole owner. He continued to operate the furnace until his death in 1854. It has since been abandoned. In 1828 Mr. Balliet and Mr. Helfrick built Penn forge, in East Penn township, Carbon county, which was also jointly conducted by them until the death of Mr. Helfrick, and subsequently by Mr. Balliet until his death. In 1837 Mr. Balliet built Penn furnace, near the forge. About 1858 this furnace was purchased by John Balliet, a son of Stephen Balliet, by whom it is still owned and operated. It is now called East Penn furnace, and is the only charcoal furnace now in operation in the Lehigh valley.

In the collection of the foregoing details concerning the iron enterprises of the Heimbachs and Stephen Balliet and Samuel Helfrick we have had the assistance of Mr. Austin N. Hungerford, of Ithaca, New York.

Two charcoal bloomaries were built in Carbon county after the beginning of the anthracite era—Anthony's, in the Lehigh Gap, in 1843, and Pine Run, at Lehighton, in 1848. A bloomary forge called Analomink was built near Stroudsburg, in Monroe county, in 1829. In 1843 Day styled it a "large forge." All of the forges and bloomaries in the Lehigh valley have been abandoned. Nearly all of the bloomaries were supplied with ore from Northern New Jersey.

In 1836 a rolling mill and wire mill were built at South Easton, in Northampton county, by Stewart & Co. This was probably the first rolling mill in the Lehigh valley.

Schuylkill county has had several forges, the first of which, near Port Clinton, appears to have been built in 1801. In 1796 a small charcoal furnace was built by Reese & Thomas at Schuylkill Gap, near Pottsville. In 1806 it was purchased by John Pott, the founder of Pottsville, who tore it down and in 1807 erected Greenwood furnace and forge in its stead. In 1832 there were in operation in Schuylkill county Greenwood furnace and forge, and Schuylkill, Brunswick, Pine Grove, Mahanoy, and Swatara forges. Swatara furnace, six miles from Pine Grove, and Stanhope furnace, still nearer to Pine Grove, were built between 1830 and 1840. About 1840 Jefferson furnace, at Schuylkill Haven, was built. All of these charcoal enterprises in Schuylkill county have been abandoned.

In 1805 there were two forges in York county, one of which was Spring forge; we can not locate the other. Castle Fin forge, at first called Palmyra forge, on Muddy creek, in York county, was built in 1810, by a person named Withers, and rebuilt in 1827 by Thomas Bird Coleman, who also added a blister steel furnace about 1832. Both have been abandoned. In its day Castle Fin forge was a very prominent enterprise. In 1850 there were five furnaces and three forges in this county. Since then its iron industry has sensibly declined.

Chestnut Grove furnace, at Whitestown, in Adams county, was built in 1830, and is still active. About 1830 Maria furnace was built in Hamiltonban township, by Stevens & Paxton, (Thaddeus Stevens,) but it was abandoned about 1837.

The first furnace in Franklin county was Mount Pleasant, in Path valley, about three miles north of Loudon, which was built in 1783 by three brothers, William, Benjamin, and George Chambers. A forge was also erected by them about the same time. The furnace was abandoned in 1834, and the forge in 1843. A furnace called Richmond, built in 1865, now occupies the site of Mount Pleasant furnace. Soundwell forge, on Conodoguinet creek, at Roxbury, sixteen miles north of Chambersburg, was built in 1798 by Leephar, Crotzer & Co., and was active as late as 1857. Roxbury furnace, at or near the same place, was built in 1815 by Samuel Cole, and is now abandoned. Carrick forge, four miles from Fannettsburg, was built in 1800, and was in operation in 1856. Carrick furnace, which is still active, was built in 1828 by General

Samuel Dunn and Thomas G. McCulloh. Loudon furnace and forge were built about 1790 by Colonel James Chambers, and abandoned about 1840. Valley forge, near Loudon, in this county, was built in 1804. A furnace of the same name was built near the forge at a later day. Both have been abandoned. Mont Alto furnace, in the same county, was built in 1807 by Daniel and Samuel Hughes, and is still active. Two forges of the same name, about four miles from the furnace, were built in 1809 and 1810, and were abandoned in 1866. A foundry was built in 1815, a rolling mill in 1832, and a nail factory in 1835. In 1850 the nail factory was burned down, and in 1867 the rolling mill was abandoned. The foundry and a new steam forge close to the furnace are still active.

Caledonia forge, in Franklin county, on Conococheague creek, ten miles southeast of Chambersburg, was built in 1830 by Stevens & Paxton. Caledonia furnace, at the same place, was built in 1837 by the same firm, after the abandonment of Maria furnace, in Adams county. For many years previous to 1863 this furnace and forge were owned by Hon. Thaddeus Stevens, in which year they were burned by the Confederates, under General Lee, when on the march to Gettysburg. Franklin furnace, in St. Thomas township, was built by Peter and George Housum in 1828, and is still running with charcoal. There were a few other pioneer charcoal furnaces and forges in this county. Early in the present century nails and edge tools were made in large quantities at several establishments at Chambersburg and in its vicinity. One of these, the Conococheague rolling mill and nail factory, was established by Brown & Watson in 1814.

Liberty forge, at Lisburn, on Yellow Breeches creek, in Cumberland county, was built in 1790, and is still active. An older forge, long abandoned, is said to have been built at Lisburn in 1783. A few other forges in Cumberland county were built prior to 1800. Cumberland furnace, ten miles southwest of Carlisle, on Yellow Breeches creek, is said to have been built in 1794 by Michael Ege. It blew out permanently in 1854. Holly furnace, at Papertown, in the same county, is said to have been built about 1785 by Stephen Foulk and William Cox, Jr. A forge was in existence here in 1848. The furnace was torn down in 1855 to give place to a paper

mill. It was once owned by Michael Ege. Two furnaces, now abandoned, once stood near Shippensburg in this county—Augusta, built in 1824, and Mary Ann, built in 1826. Big Pond furnace, built in 1836, between Augusta and Mary Ann furnaces, was burned down in 1880. About 1806 Jacob M. Haldeman removed from Lancaster county to New Cumberland, at the mouth of Yellow Breeches creek, on the Susquehanna. He purchased a forge at this place and added a rolling and slitting mill, which were operated until about 1826, when they were abandoned. Fairview rolling mill, about a mile from the mouth of Conodoguinet creek, in Cumberland county, and two miles above Harrisburg, was built in 1833 by Gabriel Heister and Norman Callender, of Harrisburg, to roll bar iron. Jared Pratt, of Massachusetts, leased the mill in 1836 and added a nail factory.

Michael Ege was for many years the most prominent ironmaster in the Cumberland valley, owning, a short time before his death, Pine Grove furnace, the Carlisle iron works, Holly furnace, and Cumberland furnace. He died on August 31, 1815. He was a brother of George Ege, already mentioned. Both were natives of Holland.

In 1840 there were eight furnaces and eleven forges, bloomaries, and rolling mills in Franklin county, and six furnaces and five forges and rolling mills in Cumberland county.

In 1785 Henry Fulton established a "nailery" in Dauphin county, probably at Harrisburg. It is said to have been "only a little remote from a smithy." In 1805 there were two furnaces and two forges in this county. Oakdale forge, at Elizabethville, appears to have been built in 1830. Victoria furnace, on Clark's creek, was probably built in that year. In 1832 there were three forges and two furnaces in the county. Emeline furnace, at Dauphin, was built about 1835. The first furnace at Middletown, in this county, was built in 1833, and a second furnace was built in 1849—both charcoal furnaces. Manada furnace, at West Hanover, was built in 1837 by E. B. & C. B. Grubb. The first rolling mill in the county was the Harrisburg mill, at Harrisburg, built in 1836.

North of Harrisburg, in the Susquehanna valley, the manufacture of iron had a very early beginning. About 1778 a bloomary forge was built on Nanticoke creek, near the lower

end of Wyoming valley, in Luzerne county, by John and Mason F. Alden. Another bloomary forge was erected in 1789 on the Lackawanna river, about two miles above its mouth, by Dr. William Hooker Smith and James Sutton. Still another bloomary forge was erected in 1799 or 1800, on Roaring brook, at Scranton, then called Slocum's Hollow, by two brothers, Ebenezer and Benjamin Slocum. The product of all these bloomaries was taken down the Susquehanna river in Durham boats. They continued in operation until about 1828.

Esther furnace, about three miles south of Catawissa, on East Roaring creek, in Columbia county, was built in 1802 by Michael Bitter & Son, who are said to have cast many stoves. In 1836 it was rebuilt by Trago & Thomas. In 1811 Francis McShane established a small cut-nail factory at Wilkesbarre, "and used anthracite coal in smelting the iron." Catawissa furnace, near Mainville, in Columbia county, was built in 1815, and in 1824 a forge was built near the same place. The furnace has been abandoned, but the forge, called Mainville forge, is still in operation, producing blooms for boiler plates.

A furnace was built in Lycoming county in 1820, four miles from Jersey Shore, and named Pine Creek furnace. In 1832 it was owned by Kirk, Kelton & Co. A forge was added to this furnace in 1831. Heshbon forge, on Lycoming creek, five miles above its mouth, was built in 1828, and was soon followed by other iron enterprises on the same stream. Washington furnace, at Lamar, on Fishing creek, in Clinton county, was built in 1810 by John Dunlop, who added a forge in 1812. John Dunlop was killed in a mine bank in 1815. In 1812 Nathan Harvey built a forge at Mill Hall, in Clinton county, to which a furnace was afterwards added. A furnace at Farrandsville, near the mouth of Lick run, in this county, which was built about 1836 to use coke, is said to have sunk, in connection with a nail mill, foundry, and other enterprises, over half a million dollars, contributed by Boston capitalists.

In 1814 Peter Karthaus, a native of Hamburg, in Germany, but afterwards a merchant of Baltimore, and Rev. Frederick W. Geissenhainer, a native of Mühlberg, in Saxony, established a furnace at the mouth of the Little Moshannon, or Mosquito creek, in the lower end of Clearfield county. The firm of Karthaus & Geissenhainer was dissolved

on the 18th of December, 1818. It had been organized in 1811, partly to mine and ship to eastern markets the bituminous coal of Clearfield county. The furnace was operated with partial success for several years.

Lackawanna county owes its present prominence in the iron industry mainly to the courage, energy, and business sagacity of two brothers, George W. and Selden T. Scranton, and their cousin, Joseph H. Scranton, the two brothers commencing operations in 1840 at Scranton, and their cousin joining them soon afterwards.

The foregoing summary of early iron enterprises in the Susquehanna valley could be very much extended by including other charcoal iron works and several rolling mills that were erected from about 1820 to 1850 in the counties of Lackawanna, Luzerne, Columbia, Montour, Northumberland, Union, Snyder, Lycoming, and Clinton, and most of which have now been abandoned, but this is not necessary. Our object in this chapter has been simply to preserve the names, location, and date of erection of the earliest charcoal iron enterprises that were established in Eastern and Central Pennsylvania outside of the Juniata valley after the Revolution.

We may properly close this chapter by giving some information concerning the primitive method of transporting iron and other articles by pack-horses from Cumberland and Franklin counties to the headwaters of the Ohio river at the close of the last century and after the beginning of the present century, when wagon roads were rare in Central and Western Pennsylvania. The following account is taken from Rupp's *History of Cumberland County*, published in 1848.

Sixty or seventy years ago 500 pack-horses had been at one time in Carlisle, going thence to Shippensburg, Fort Loudon, and further westward, loaded with merchandise, also salt, iron, etc. The pack-horses used to carry bars of iron on their backs, crooked over and around their bodies; barrels or kegs were hung on each side of these. Colonel Snyder, of Chambersburg, in a conversation with the writer in August, 1845, said that he cleared many a day from $6 to $8 in crooking or bending iron and shoeing horses for Western carriers, at the time he was carrying on a blacksmith shop in the town of Chambersburg. The pack-horses were generally led in divisions of 12 or 15 horses, carrying about two hundred-weight each, all going single file and being managed by two men, one going before as the leader and the other at the tail to see after the safety of the packs. Where the bridle road passed along declivities or over hills, the path was in some

places washed out so deep that the packs or burdens came in contact with the ground or other impeding obstacles, and were frequently displaced. However, as the carriers usually traveled in companies, the packs were soon adjusted and no great delay occasioned. The pack-horses were generally furnished with bells, which were kept from ringing during the day drive, but were let loose at night when the horses were set free and permitted to feed and browse. The bells were intended as guides to direct their whereabouts in the morning. When wagons were first introduced, the carriers considered that mode of transportation an invasion of their rights.

Day, in his *Historical Collections*, says that "Mercersburg, in Franklin county, was in early days an important point for trade with Indians and settlers on the Western frontier. It was no uncommon event to see there 50 or 100 pack-horses in a row, taking on their loads of salt, iron, and other commodities for the Monongahela country." In 1789 the crank for the first saw-mill built in Ohio was carried by pack-horses over the mountains to the Youghiogheny river, and thence shipped by water to its destination on Wolf creek, sixteen miles from Marietta. It weighed 180 pounds, and was made in New Haven, Connecticut, for the New England Ohio Company.

CHAPTER XIV.

THE MANUFACTURE OF CHARCOAL IRON IN THE JUNIATA VALLEY.

As early as 1767 a company called The Juniata Iron Company was organized, apparently by capitalists of Eastern Pennsylvania, to search for iron ore in the Juniata valley, and probably with the ulterior object of manufacturing iron. It was in existence from 1767 to 1771, during which time its agent, Benjamin Jacobs, made for it some surveys and explorations and dug a few tons of iron ore, but where these operations were conducted and who were the members of this pioneer company some future antiquarian must discover.

The first iron enterprise in the Juniata valley was Bedford furnace, on Black Log creek, below its junction with Shade creek, at Orbisonia, in Huntingdon county, which was soon followed by Bedford forge, on Little Aughwick creek, four miles southwest of the furnace. The furnace and forge derived their name from Bedford county, which then embraced Huntingdon county, the latter county not having been organized until 1787. George Ashman was the leading spirit in originating and promoting these enterprises. He was a large owner of land at Orbisonia in 1780, and at this time or soon afterwards he became interested in the iron-ore deposits which had been discovered on his property. On November 8 and 9, 1786, he entered into an agreement with Charles Ridgely, Thomas Cromwell, and Tempest Tucker, all apparently of Washington county, Maryland, for the sale to them of "three-fourths of two tracts of land, called Bedford and Black Log tracts," upon which a saw mill and grist mill had been erected, retaining the other fourth himself, upon which tracts it was agreed that "an iron works" should be built. The erection of a furnace appears to have been immediately undertaken. Mr. Tucker died in 1788, and was the first man buried at Orbisonia. The company thereafter consisted of Edward Ridgely, (son of Charles Ridgely,) Thomas Cromwell, and George Ashman. The furnace was probably completed in 1788. It

was certainly in operation before 1790, as on the 2d day of March of that year Hugh Needy entered into an agreement with the company to deliver twenty-eight ten-gallon kettles and seven Dutch ovens, the whole weighing 12 cwt., 3 qrs., and 21 lbs., to Daniel Depue, "on or near the Monongahela river, near Devor's Ferry, in eight days ensuing the date hereof." These articles were carried on pack-horses. The forge appears to have been built in 1791, as is shown by an itemized statement of iron made by the company from "the time the forge started" in that year until October 12, 1796—the product in these six years being 497 tons, 8 cwt., 2 qrs., and 26 lbs.

For the foregoing details we are indebted to C. R. McCarthy, Esq., of Saltillo, Huntingdon county. The following additional details are gathered from other sources. The furnace was of small capacity, and constructed partly of wood. When it was not engaged in producing castings it made from eight to ten tons of pig iron weekly. The forge made horseshoe iron, wagon tire, harrow teeth, etc. Large stoves as well as other utensils were cast at the furnace. At the Philadelphia Exhibition of 1876 a stove-plate cast at this furnace in 1792 was exhibited. Bar iron made at Bedford forge was bent into the shape of the letter U, turned over the backs of horses, and in this manner taken by bridle-paths to Pittsburgh. Bar iron and castings from Bedford furnace and forge, and from later iron works in the Juniata valley, were also taken down the Juniata river in arks, many of which descended to Middletown on the Susquehanna, whence the iron was hauled to Philadelphia or sent in arks down the Susquehanna to Baltimore. Bedford furnace and forge were abandoned early in the present century. Three other charcoal furnaces, all now abandoned, have since been built at or near its site. One of these was Rockhill furnace, on Black Log creek, three-quarters of a mile southeast of Orbisonia, built in 1830. It was in operation in 1872, but in the following year it gave place to two coke furnaces built by the Rockhill Iron and Coal Company.

Centre furnace, on Spring creek, in Centre county, was the second furnace in the Juniata valley. It was built in the summer of 1791 by Colonel John Patton and Colonel Samuel Miles, both Revolutionary officers. The first forge in Centre county was Rock forge, on Spring creek, built in 1793 by General

Philip Benner. A rolling and slitting mill, nail factory, another forge, etc., were soon added. General Benner had made iron at Nutt's forge at Coventry after the Revolution. He died at Rock on July 27, 1832, aged 70 years. In 1852 the extensive works which he had established were abandoned. In 1795 Daniel Turner built Spring Creek forge, and Miles, Harris & Miles built Harmony forge, also on Spring creek. In 1798 John Dunlop built Bellefonte forge, which is now owned and operated by Valentines & Co., and in 1802 he built Logan furnace, three miles south of Bellefonte. In 1824 Valentines & Thomas added a rolling mill to the Bellefonte forge. Tussey furnace, in Ferguson township, was built in 1810 by General William Patton, son of Colonel Patton. In 1810 Roland Curtin, a native of Ireland, and father of Governor Andrew G. Curtin, in company with Moses Boggs, erected Eagle forge, on Bald Eagle creek, about five miles from Bellefonte, Boggs remaining a partner only a short time. In 1818 he built Eagle furnace near his forge. In 1830 a small rolling mill was added, for the manufacture of bar iron and nails, and in the same year he built Martha furnace, on Bald Eagle creek, which has long been abandoned. His other works are still in operation and are owned by his children and grandchildren. He died in 1850, aged 86 years. In 1817 Hardman Philips, an enterprising Englishman, erected a forge and screw factory at Philipsburg, the latter being one of the first of its kind in this country. Cold Stream forge, in Rush township; Hecla furnace, near Hublersburg; Hannah furnace, about ten miles northeast of Tyrone; and Julian furnace, on Bald Eagle creek, all in Centre county, were built between 1825 and 1840. In 1829 a furnace was built at Howard by Harris, Thomas & Co., to which a rolling mill was added in 1840. The works at Howard are now owned and operated by Bernard Lauth.—The Hon. John B. Linn has kindly verified the foregoing dates.

Barree forge, on the Juniata, in Huntingdon county, was built about 1794 by Bartholomew & Dorsey, to convert the pig iron of Centre furnace into bar iron. Huntingdon furnace, on Warrior's Mark run, in Franklin township, was built in 1796, but after one or two blasts it was removed a mile lower down the stream. The furnace was built for Mordecai Massey and Judge John Gloninger by George Anshutz, who

in 1808 became the owner of one-fourth of the property. At the same time George Shoenberger purchased a one-fourth interest. Prior to 1808 Martin Dubbs had become a part owner. A forge called Massey, on Spruce creek, was connected with Huntingdon furnace, and was built about 1800. The furnace has been silent since 1870. Tyrone forges, on the Juniata, were built by the owners of Huntingdon furnace—the first of the forges in 1804. Gordon, in 1832, in his *Gazetteer of the State of Pennsylvania,* stated that these forges, with a rolling and slitting mill and nail factory attached, formed "a very extensive establishment," owned by Messrs. Gloninger, Anshutz & Co. "The mill rolls about 150 tons, 75 of which are cut into nails at the works, 50 tons are slit into rods and sent to the West, and about 25 tons are sold in the adjoining counties."

Juniata forge was built at Petersburg about 1804 by Samuel Fahnestock and George Shoenberger, the latter becoming sole owner in 1805. George Shoenberger was born in Lancaster county, and during the closing years of the last century settled on Shaver's creek, in Huntingdon county, as did also his brother Peter. The town of Petersburg was laid out in 1795 by Peter Shoenberger. In 1800 Peter sold to his brother George the Petersburg tract of land. George Shoenberger died in 1814 or 1815. His only son, Dr. Peter Shoenberger, succeeded him in the ownership of his iron enterprises.

Coleraine forges, on Spruce creek, were built in 1805 and 1809, by Samuel Marshall. There have been many forges on Spruce creek, none of which are now in operation. Union furnace, in Morris township, and Pennsylvania furnace, on the line dividing Huntingdon from Centre county, were built soon after 1810; the latter has recently been in operation, using coke. About 1818 Reuben Trexler, of Berks county, built a bloomary called Mary Ann, in Trough Creek valley, and about 1821 he added Paradise furnace. In 1832 John Savage, of Philadelphia, built a forge near Paradise furnace, which is said to have been the first forge in this country "that used the big hammer and iron helve on the English plan."

Etna furnace and forge, on the Juniata, in Catharine township, Blair county, were built in 1805 by Canan, Stewart & Moore. The furnace was the first in Blair county. Cove forge,

on the Frankstown branch of the Juniata, was built between 1808 and 1810 by John Royer, who died at Johnstown in 1850, aged about 71 years. Allegheny furnace was built in 1811 by Allison & Henderson, and was the second furnace in Blair county. In 1835 it was purchased by Elias Baker and Roland Diller, both of Lancaster county. The next furnace in Blair county was Springfield, built in 1815 by John Royer and his brother Daniel. Springfield furnace and Cove forge are now owned by John Royer, born in 1799, son of Daniel. The next furnace in this county was Rebecca, built in 1817. It was the first furnace erected by Dr. Peter Shoenberger, who afterwards became the most prominent ironmaster in Pennsylvania. The doctor was born at Manheim, Lancaster county, in 1781; died at Marietta, Lancaster county, on June 18, 1854, aged 73 years; and was buried in Laurel Hill cemetery, Philadelphia.

Elizabeth furnace, near Antestown, in Blair county, is said to have been the first furnace in the country to use gas from the tunnel-head for the production of steam. The furnace was built in 1832, and the improvement was patented about 1840 by Martin Bell, the owner of the furnace.

A furnace and forge were built at Hopewell, in Bedford county, about the year 1800, by William Lane, of Lancaster county. On Yellow creek, two miles from Hopewell, Mr. Lane built Lemnos forge and slitting mill in 1806; they were in operation as late as 1833. In 1841 Loy & Patterson built Lemnos furnace, on the same creek, two miles west of Hopewell. Bedford forge, on Yellow creek, was built by Swope & King in 1812. Elizabeth furnace was built at Woodbury, in Bedford county, in 1827, by King, Swope & Co. In 1845 it was removed to Bloomfield, Blair county, but it is now abandoned. In 1840 Bedford county, which then embraced Fulton county and a part of Blair county, contained nine furnaces and two forges. Hanover furnace and forge, nine miles below McConnellsburg, in Fulton county, were known as the Hanover iron works. The forge was built in 1822 by John Doyle, and the furnace in 1827 by John Irvine. Both were abandoned about 1850. The account books of the Hanover iron works from 1831 to 1833 have recently been discovered. Among the frequent charges in them against the workmen is

whisky, in quantities of from one to five gallons, at $33\frac{1}{3}$ cents per gallon. Flour is charged at $3.50 per barrel, and boarding at $1.40 per week; James Downs is charged with $6 "paid him to git married." There are now no iron enterprises in Fulton county.

Steel (probably blister steel) was made at Caledonia, near Bedford, for several years before the beginning of this century by William McDermett, who was born near Glasgow, in Scotland, and came to this country at the close of the Revolutionary war. Mr. McDermett's works continued in successful operation for about ten years, when financial reverses caused their abandonment. A few years later he removed to Spruce creek, in Huntingdon county, and there ended his days about 1819. Josephine, one of his daughters, married, in 1820, David R. Porter, then a young ironmaster on Spruce creek, but afterwards Governor of Pennsylvania. About 1818 David R. Porter and Edward B. Patton built Sligo forge, on Spruce creek. After Mr. McDermett's removal to Spruce creek a forge and steel works, called Claubaugh, were built on the creek by his nephew, Thomas McDermett, at which steel was made by the process that had been in use at Caledonia. These works became the property of Lloyd, Steel & Co. about 1819, by whom they were abandoned in a few years.

There was a very early forge in Juniata county. It was built in 1791 on Licking creek, two miles west of Mifflintown, by Thomas Beale and William Sterrett. It had two hammers and was in operation about four years. The pig iron for this forge was obtained mainly from Centre furnace, but some was brought from Bedford furnace.

Hope furnace, a few miles from Lewistown, and Freedom forge, three miles from the same place, were built in 1810, and were probably the first iron enterprises within the present limits of Mifflin county. General James Lewis was one of the proprietors of Hope furnace. In 1832 there were three furnaces and one forge in Mifflin county, and in 1850 there were five furnaces and two forges.

The first iron enterprise in Perry county was Mount Vernon forge, on Cocalamus creek, built in 1807 or 1808 by General Lewis, and abandoned about 1817. It had two fires and two hammers. Juniata furnace, three miles from Newport,

was built in 1808 by David Watts, of Carlisle. In 1832 it was owned by Captain William Power. A forge called Fio was built on Sherman's creek, about four miles from Duncannon, in 1829, by Lindley & Speek. A forge was also built at Duncannon in the same year by Stephen Duncan and John D. Mahon. Duncannon rolling mill was built in 1838 by Fisher, Morgan & Co. Montebello furnace, at Duncannon, Oak Grove, four miles from Landisburg, Caroline, at Baileysburg, and Perry, four miles from Bloomfield, all in Perry county, were built between 1830 and 1840. All of the charcoal iron enterprises in Perry county have been abandoned.

Many other charcoal furnaces and forges and a few rolling mills were built in the upper part of the Juniata valley before 1850. In 1832 there were in operation in Huntingdon county, which then embraced Blair county, eight furnaces, ten forges, and one rolling and slitting mill. Each of the furnaces yielded from 1,200 to 1,600 tons of iron annually. In the same year an incomplete list enumerated eight furnaces and as many forges in Centre county. In 1850 there were in Huntingdon, Centre, Mifflin, and Blair counties (the last formed out of Huntingdon and Bedford in 1846) forty-eight furnaces, forty-two forges, and eight rolling mills, nearly all of which were in Huntingdon and Centre counties. Most of these enterprises have been abandoned.

Among the persons who have been prominent in the manufacture of iron in the Juniata valley special reference may be made, in addition to those already mentioned, to Henry S. Spang, John Lyon, Anthony Shorb, Andrew Gregg, and General James Irvin.

Most of the iron made in the Juniata valley during the palmy days of its iron industry was sold at Pittsburgh, at first in the form of bars, afterwards in both pigs and bars, and finally chiefly in the form of blooms. Before the completion of the Pennsylvania Canal and the Portage Railroad it was transported with great difficulty. Bar iron from Centre county was at first carried on the backs of horses to the Clarion river, and was then floated on boats and arks to Pittsburgh. Pig iron and bar iron from Huntingdon county were hauled over the Frankstown road to Johnstown, and thence floated to Pittsburgh by way of the Conemaugh river.

CHAPTER XV.

THE MANUFACTURE OF CHARCOAL IRON IN WESTERN PENNSYLVANIA EXCEPT ALLEGHENY COUNTY.

THE earliest mention we have found of the existence of iron ore in Western Pennsylvania occurs in the careful investigations of Mr. Austin N. Hungerford into the early history of Fayette county. We quote from him the following interesting particulars. It will be seen that the facts cited antedate the settlement, on September 23, 1780, of the boundary dispute between Pennsylvania and Virginia.

There is a tradition that the first discovery of iron ore west of the Allegheny mountains was made by John Hayden in the winter of 1789-90. This statement has been so often made in the writings of Judge Veech and others without contradiction that it has come to be almost universally regarded as entirely authentic. That such is not the case, however, and that iron ore was known to exist in the valley of the Youghiogheny at least nine years before the alleged first discovery by Hayden, is proved by an entry found in the First Survey Book of Yohogania county, Va., and made a century ago by Col. William Crawford, then surveyor of the said county. The following is a copy of the entry:

"July 11, 1780. No. 32.—State Warrant.—Benjamin Johnston produced a State Warrant from the Land Office for five hundred acres of land, dated the 12th day of May, 1780—No. 4926. Sixty acres thereof he locates on a big spring in the Allegany and Laurel Hills, on the waters of the Monongalia—and one hundred and fifty acres of s[d] Warrant he locates on lands of s[d] Hills, where an old deadening and Sugar Camp was made by Mr. Chr. Harrison, situate on the waters of Yohogania, to include a Bank of Iron Ore."

Yohogania county, as established by the Virginia Legislature in 1776, included all the northern and northeastern part of the present county of Fayette. The Survey Book referred to is still in existence in a good state of preservation, and in possession of Boyd Crumrine, Esq., of Washington, Pa.

The precise location of the tract referred to as including the ore-bank is not known, nor is it material. The quotation is given above merely to disprove the long-accepted statement that the existence of iron ore west of the Alleghenies was unknown prior to 1789.

The Hon. James Veech, to whom reference is above made, published in the *Pittsburgh Commercial*, on the 29th of March, 1871, an account of the discovery of "blue lump" iron ore by John Hayden, of Haydenville, in Fayette county, in 1790,

from which he made in a smith's fire a piece of iron "about as big as a harrow-tooth." Taking this sample on horseback to Philadelphia, he enlisted his relative, John Nicholson, of that city, then state comptroller, in a scheme for building a furnace and forge, on George's creek, about seven miles south of Uniontown. Mr. Hungerford says that a bloomary was built by this firm in 1792, but that it never built a furnace. Before this bloomary was built William Turnbull and Peter Marmie, with Colonel John Holker as a silent partner, all of Philadelphia, built a furnace and a forge on Jacob's creek, a mile or two above its entrance into the Youghiogheny river. The court records of Fayette county mention "the furnace on Jacob's creek" in June, 1789, but it had not then been put in blast. It was first blown in on November 1, 1790, and the iron was tried the same day in the forge. The furnace and forge were on the Fayette county side of the creek, and were called the Alliance iron works. The furnace was successfully operated for many years, and the stack is still standing, but in ruins. This was undoubtedly the first furnace west of the Allegheny mountains. An extract from a letter written by Major Craig, deputy quartermaster-general and military storekeeper at Fort Pitt, to General Knox, dated January 12, 1792, says: "As there is no six-pound shot here, I have taken the liberty to engage four hundred at Turnbull & Marmie's furnace, which is now in blast." It is said that shot and shells for General Wayne's expedition against the Indians in 1792 were supplied by Turnbull & Marmie.

Union furnace, now Dunbar furnace, on Dunbar creek, four miles south of Connellsville, was built by Colonel Isaac Meason in 1790, and was put in blast in March, 1791. A forge was connected with this furnace. It was succeeded in 1793 by a larger furnace of the same name, built near the same site by Colonel Meason, John Gibson, and Moses Dillon. An advertisement in the *Pittsburgh Gazette*, dated April 10, 1794, mentions that Meason, Dillon & Co. have for sale "a supply of well-assorted castings, which they will sell for cash at the reduced price of £35 per ton ($93.33)." Another of Colonel Meason's enterprises was Mount Vernon furnace, on Mountz's creek, eight miles east of its mouth, built before July, 1800. It was rebuilt in 1801. It is still standing, but abandoned.

Spring Hill furnace, on Ruble's run, in Fayette county, within three miles of Cheat river, in West Virginia, and near its confluence with the Monongahela, was built in 1794 by two Welshmen, Benjamin and Robert Jones. This furnace was in operation until 1881, but in 1883 it was dismantled. About 1797 Old Laurel furnace, on Laurel run, in Dunbar township, was built by Joshua Gibson and Samuel Paxson. This furnace passed into the possession of Reuben Mochabee and Samuel Wurtz before 1800, who added Hampton forge. Pine Grove forge, on Pine Grove run, in George's township, was built a short time prior to 1798 by Thomas Lewis. Prior to 1794 Jeremiah Peairs built a forge at Plumsock, in Menallen township, which was the forerunner of a rolling and slitting mill built by Mr. Peairs at the same place before 1804. In 1805 the rolling and slitting mill and the remainder of Mr. Peairs's property were sold by the sheriff. This was probably the first rolling and slitting mill erected west of the Alleghenies. In 1815 the Plumsock property passed into the hands of Colonel Isaac Meason. In 1797 Mr. Peairs built Old Redstone furnace, in South Union township, Fayette county. The dilapidated stack of this furnace is still standing.

In 1797 John Hayden built Fairfield furnace, on George's creek. John and Andrew Oliphant and Nathaniel Breading bought an interest in this furnace in 1798, and in a few years the Oliphants became its sole owners. Fairchance furnace, on George's creek, six miles south of Uniontown, was built in 1804 by John Hayden, William Squire, and Thomas Wynn. J. & A. Oliphant bought it about 1805. It was rebuilt two or three times and kept in operation until 1873. The last-named firm built Sylvan forges, on George's creek, below Fairfield and Fairchance furnaces. It is said that while the Oliphants operated Fairfield furnace they furnished from it a quantity of shot which was used by General Jackson's artillery in the battle of New Orleans. It was shipped down the Monongahela, the Ohio, and the Mississippi rivers.

In 1805 there were five furnaces and six forges in Fayette county. In 1806 a rolling and slitting mill had been built by John Gibson on the right bank of the Youghiogheny, below Connellsville. In 1811 the county had ten furnaces, one air furnace, eight forges, three rolling and slitting mills, one

steel furnace, and five trip-hammers. At a later date there were twenty furnaces in this county. Fayette county was a great iron centre at the close of the last century and far into the present century. For many years Pittsburgh and the Ohio and Mississippi valleys were almost entirely supplied by it with castings of all kinds, and with pig and bar iron. In 1804 a large order for sugar-kettles, to be used on the sugar plantations of Louisiana, was filled at Union furnace. Long before 1850, however, the fires in most of the furnaces and forges of Fayette county were suffered to die out. In 1849 only four of its furnaces were in blast. Other furnaces, to use coke, have since been built within its boundaries, but its fame as a centre of the iron industry has departed. In its stead it now enjoys the reputation of being the centre of production of the far-famed Connellsville coke.

The steel furnace above referred to was at Bridgeport, adjoining Brownsville, was owned by Truman & Co., and made good steel. It was known as the Brownsville Steel Factory. In 1811 Truman & Co. advertised that they had for sale "several tons of steel of their own converting, which they will sell at the factory for cash, at 12 dollars per cwt., and 20 dollars per faggot for Crowley." The latter was an English brand.

The first nail factory west of the Alleghenies was built at Brownsville, about 1795, by Jacob Bowman, at which wrought nails were made by hand in one shop and cut nails were made by machines in another. These machines were worked by the foot of the workman, while his hands guided the flat thin bar of iron from which the nails were cut.

The rolling and slitting mills which were in existence in Pennsylvania prior to 1816 neither puddled pig iron nor rolled bar iron, but, with the exception of Mr. Rentgen's enterprise, already noted, rolled only sheet iron and nail plates from blooms hammered under a tilt-hammer.

The first rolling mill erected in the United States to puddle iron and roll iron bars was built by Colonel Isaac Meason in 1816 and 1817, at Plumsock, on Redstone creek, about midway between Connellsville and Brownsville, in Fayette county. Thomas C. Lewis was the chief engineer in the erection of the mill, and George Lewis, his brother, was the turner and roller. They were Welshmen. F. H. Oliphant told us in his

lifetime that the mill was built "for making bars of all sizes and hoops for cutting into nails." He further said that "the iron was refined by blast, and then puddled." Samuel C. Lewis, the son of Thomas C. Lewis, assisted as a boy in rolling the first bar of iron. He died at Pittsburgh on Friday, August 11, 1882, in the 80th year of his age. The mill contained two puddling furnaces, one refinery, one heating furnace, and one tilt-hammer. Raw coal was used in the puddling and heating furnaces, and coke in the refinery. The rolls were cast at Dunbar furnace, and the lathe for turning the rolls was put up at the mill. The mill went into operation on September 15, 1817, and was kept in operation until 1824, the latter part of the time by a Mr. Palmer. A flood in the Redstone then caused the partial destruction of the mill. The machinery was subsequently taken to Brownsville.

Colonel Meason, who did so much to develop the iron resources of Fayette county, was a native of Virginia. His wife was a Miss Harrison, of that State. He died in 1819.

A furnace named Mary Ann was erected in Greene county at a very early day, on Ten-mile creek, opposite Clarksville, and about twenty miles from Uniontown. It was abandoned early in the present century. An advertisement for its sale, by "Samuel Harper, agent for the proprietors," dated July 23, 1810, calls it "The Iron Works," late the property of Captain James Robinson. It was probably built about 1800. Gordon, in his *Gazetteer*, (1832,) says that "there were formerly in operation on Ten-mile creek a forge and furnace, but they have been long idle and are falling to decay." This reference is to Robinson's works. Greene county has probably never had any other iron enterprises within its limits.

Westmoreland county speedily followed Fayette county in the manufacture of iron. Westmoreland furnace, on Four-mile run, near Laughlinstown, in Ligonier valley, was built about 1792 by John Probst, who also built a small forge about the same time. Neither the furnace nor the forge was long in operation, both probably ceasing to make iron before 1810. On the 1st of August, 1795, George Anshutz, manager of Westmoreland furnace, advertised stoves and castings for sale. General Arthur St. Clair built Hermitage furnace, on Mill creek, two miles northeast of Ligonier, about 1802. It was

managed for its owner by James Hamilton, and made stoves and other castings. It was in blast in 1806. In 1810 it passed out of the hands of General St. Clair, and was idle for some time. In 1816 it was started again by O'Hara & Scully, under the management of John Henry Hopkins, afterwards Protestant Episcopal bishop of Vermont. In October, 1817, Mr. Hopkins left the furnace, himself a bankrupt, and it has never since been in operation. The stack is still standing. General St. Clair died a very poor man in 1818, aged 84 years, and was buried at Greensburg. Mount Hope furnace, in Donegal township, was built about 1810 by Trevor & McClurg. Mount Pleasant furnace, on Jacob's creek, in Mount Pleasant township, was built about 1810 by Mr. McClurg, and went out of blast in 1820 while under the control of Mr. Freeman. Washington furnace, near Laughlinstown, was built about 1809 by Johnston, McClurg & Co. It was abandoned in 1826, but rebuilt in 1848 by John Bell & Co. It was in blast as late as 1854. Jonathan Maybury & Co. owned Fountain furnace, on Camp run, in Donegal township, at the base of Laurel hill, before 1812. The firm was dissolved on August 19, 1812. Kingston forge, erected in 1811 on Loyalhanna creek, ten miles east of Greensburg, by A. Johnston & Co., went into operation early in 1812. Ross furnace, on Tub-mill creek, in Fairfield township, was built in 1814 by Colonel Meason, and abandoned about 1850. It made pig iron, stoves, sugar-kettles, pots, ovens, skillets, etc. Hannah furnace, on Tub-mill creek, in Fairfield township, a short distance below Ross furnace, was built about 1810 by John Beninger. He also built a small forge on the same stream, where the town of Bolivar now stands. The furnace and forge both ceased to make iron soon after they were built. Baldwin furnace, on Laurel run, near Ross furnace, is said to have been built by James Stewart about 1810. It ran but a short time.

In 1832 there were in operation in Westmoreland county only one furnace, (Ross,) operated by Colonel Mathiot, and one forge, (Kingston,) operated by Alexander Johnston. The latter gentleman, whose name appears above in connection with another iron enterprise, was the father of Governor William F. Johnston. He was born in Ireland in July, 1772, and died in July, 1872, aged 100 years.

Seven other charcoal furnaces were built in Westmoreland county between 1844 and 1855. All of the charcoal furnaces in this county have been abandoned. The early Westmoreland furnaces, besides supplying local wants, shipped pig iron and castings by boats or arks on the Conemaugh and Allegheny rivers to Pittsburgh, much of which found its way down the Ohio river to Cincinnati and Louisville.

Shade furnace, on Shade creek, in Somerset county, was built in 1807 or 1808, and was the first iron enterprise in the county. It used bog ore, the discovery of which led to its erection, although the location was otherwise unfavorable. It was built by Gerehart & Reynolds upon land leased from Thomas Vickroy. In November, 1813, Mr. Vickroy advertised the furnace for sale, at a great bargain. A sale was effected in 1819 to Mark Richards, Anthony S. Earl, and Benjamin Johns, of New Jersey, constituting the firm of Richards, Earl & Co., which operated the furnace down to about 1830. In 1820 the firm built Shade forge, below the furnace, which was carried on by William Earl for four or five years, and afterwards by John Hammer and others. About 1811 Joseph Vickroy and Conrad Piper built Mary Ann forge, on Stony creek, about five miles below Shade furnace, and a half mile below the mouth of Shade creek. David Livingston was subsequently the owner of the forge, and operated it for several years. Richard Geary, the father of Governor John W. Geary, was the millwright who built the forge for the owners. Pig iron was sometimes packed on horseback to this forge from Bedford county, the horses taking salt from the Conemaugh salt works, and bar iron, as a return load. In the year 1809 or 1810 Peter Kimmell and Matthias Scott built a forge for the manufacture of bar iron on Laurel Hill creek, now in Jefferson township, in the western part of Somerset county. It ceased operations about 1815. Supplies of pig iron were obtained from Bedford and Fayette counties. About the year 1810 Robert Philson erected a forge and furnace on Casselman's river, in Turkeyfoot township. The enterprise was a failure. Four other charcoal furnaces were afterwards built in Somerset county. All of the furnaces and forges in this county have long been abandoned.

The first iron enterprise in Cambria county was a forge at

Johnstown, built on Stony creek, about 1809, by John Buckwalter. The dam of this forge was washed away about 1811, and subsequently the forge was removed to the Conemaugh river, below Johnstown, where the schoolhouse now stands on Cinder street, in Millville, and operated down to about 1822, Rahm & Bean, of Pittsburgh, being the lessees at this time. It was used to hammer bar iron out of Juniata pig iron. In 1817 Thomas Burrell, the proprietor, offered wood-cutters "fifty cents per cord for chopping two thousand cords of wood at Cambria forge, Johnstown." About 200 pounds of nails, valued at $30, were made at Johnstown by one establishment in the census year 1810. About this time an enterprise was established at Johnstown by Robert Pierson, by which nails were cut with a machine worked by a treadle, but without heads, which were afterwards added by hand. Cambria county has been noted as an iron centre since its first furnace, Cambria, was built by George S. King, David Stewart, John K. Shryock, and William L. Shryock in 1841, on Laurel run. It was followed in the next six years by five other charcoal furnaces. All of these furnaces have been abandoned. The Cambria iron works, at Johnstown, were commenced in 1853 by a company of which Mr. King was the originator and Dr. Peter Shoenberger was a member. In 1832 Gordon referred to the prospect of making iron from native ore in Cambria county as follows: "And there is iron, as it is said by some, but denied by others."

The first iron enterprise in Indiana county was Indiana forge, on Finley's run, near the Conemaugh, built about 1837 by Henry and John Noble, who also built a small furnace as early as 1840. The forge was operated by water-power, but the furnace by steam-power. Both enterprises were running in the last-named year. Pig iron for the forge was at first obtained from Allegheny furnace, in Blair county. Some iron ore for the furnace was obtained from the Allegheny furnace mines. About 1837 John Noble owned a farm of about 200 acres in the heart of the present city of Altoona, which he sold to David Robinson, of Pleasant valley, for $4,500, taking in payment the contents of Mr. Robinson's country store, which he removed to Finley's run and added to the capital stock of the firm of Henry and John Noble. The Altoona

farm is now worth many millions of dollars. About 1846 the Indiana property passed into the hands of Elias Baker, who built a new furnace and forge. Three other charcoal furnaces were built in Indiana county in 1846 and 1847. All of its furnaces and its solitary forge have long been abandoned.

A blast furnace was built at Beaver Falls, on the west side of Beaver river, in Beaver county, in 1802, by Hoopes, Townsend & Co., and was blown in in 1804. A forge was connected with it from the beginning, and was in operation in 1806. The furnace and forge were in operation in 1816. The whole enterprise was abandoned about 1826. The ore used was picked out of gravel banks in the neighborhood in very small lumps. There was another early furnace in Beaver county, named Bassenheim, built in 1814 by Detmar Basse Muller, on Connoquenessing creek, about a mile west of the Butler county line. In February, 1818, $12 per ton was paid for hauling the pig metal made at this furnace to Pittsburgh, thirty miles distant, over a bad road. The furnace was abandoned at an early day. John Henry Hopkins, previously mentioned in connection with General St. Clair's furnace near Ligonier, was engaged about 1815 as a clerk at Bassenheim furnace.

Prior to 1846 there were a few furnaces in the Shenango valley, all charcoal, one of which was Springfield furnace, half a mile from Leesburg and seven miles southeast of Mercer, built in 1837 and active in 1849. Day, in 1843, says: "Two furnaces were wrought formerly, but have since been abandoned." In 1806 the geographer Joseph Scott says that "a forge and furnace are now nearly erected" at New Castle. About 1810 there was a forge on Neshannock creek, "midway between Pearson's flour mill and Harvey's paper mill," for the manufacture of bar iron from the ore. The first rolling mill in Lawrence county was built in 1839 at New Castle by James D. White, of that place, under the superintendence of S. Wilder, a native of Massachusetts. It made cut nails and bar iron. This mill was subsequently known as Cosalo rolling mill. In 1846 and soon afterwards several furnaces were built in this valley to use its splint coal in the raw state.

The first furnace in the once important but now nearly neglected ironmaking district composed of Armstrong, Butler,

Clarion, Venango, and other northwestern counties was doubtless Bear Creek, in Armstrong county, commenced in 1818 by Ruggles, Stackpole & Whiting, who then owned the Pittsburgh rolling mill. In the following year, owing to the failure of this firm, it passed uncompleted into the hands of Baldwin, Robinson, McNickle & Beltzhoover, of Pittsburgh. The furnace went into operation in 1819. It was built to use coke, with steam-power, and its first blast was with this fuel, but the blast was too weak, and the furnace chilled after two or three tons of iron had been made. Charcoal was then successfully substituted. The furnace was abandoned long before 1850, but it was running in 1832, in which year Gordon says that it was owned by Henry Baldwin, Esq., and was reputed to be the largest furnace in the United States, having made forty tons of iron in a week. This furnace had a tram-road, with wooden rails, in 1818.

Rock furnace, on Roaring run, a tributary of the Kiskiminetas, four miles east of Apollo, in Armstrong county, was built about 1825 by James W. Biddle, of Pittsburgh, and others. It has been abandoned since 1855. Slippery Rock furnace, in Butler county, and Clarion furnace, in Clarion county, were built in 1828—the latter by Judge Christian Myers, a native of Lancaster county, who built another furnace about 1844, which he called Polk. Allegheny furnace, at Kittanning, in Armstrong county, and Venango furnace, on Oil creek, in Venango county, were built in 1830. From 1830 to 1850 this section of the State produced large quantities of charcoal pig iron. In 1850 there were eleven furnaces in Armstrong county, six in Butler, twenty-eight in Clarion, and eighteen in Venango—sixty-three in all. In 1858 there were eighteen in Armstrong, six in Butler, twenty-seven in Clarion, and twenty-four in Venango—seventy-five in all. All of these were charcoal furnaces, except four coke furnaces at Brady's Bend. Many of these furnaces had, however, been abandoned at the latter date. Nearly every one has since then been abandoned. These furnaces were mainly built to supply the Pittsburgh rolling mills with pig iron.

The Great Western iron works at Brady's Bend, embracing a rolling mill, and four furnaces to use coke, were commenced by Philander Raymond in 1840. They have been abandoned

for many years. The rolling mill was built in 1841 to roll bar iron, but it afterwards rolled iron rails.

The iron manufactured in the Allegheny valley was taken down the Allegheny river to Pittsburgh on keel-boats and arks, the business of transporting it being quite extensive.

Erie charcoal furnace, at Erie, was built in 1842 and abandoned in 1849. It used bog ore. It was owned by Charles M. Reed. Liberty furnace, on the north side of French creek, in Crawford county, was built in 1842 by Lowry & Co., of Meadville, and abandoned in 1849.

CHAPTER XVI.

EARLY IRON ENTERPRISES IN ALLEGHENY COUNTY, PENNSYLVANIA.

THE beginning of the iron industry at Pittsburgh was made at a comparatively recent period. George Anshutz, the pioneer in the manufacture of iron at Pittsburgh, was an Alsacian by birth, Alsace at the time being under the control of France. He was born near Strasburg on November 28, 1753. In 1789 he emigrated to the United States, and soon afterwards located at a suburb of Pittsburgh now known as Shady Side, where he built a small furnace on Two-mile run, probably completing it in 1792. In 1794 it was abandoned for want of ore. It had been expected that ore could be obtained in the vicinity, but the expectation was not realized, and the expense entailed in bringing ore from other localities was too great. In 1794 the fire of the furnace lighted up the camp of the participants in the whisky insurrection. The enterprise seems to have been largely devoted to the casting of stoves and grates. The ruins of the furnace were visible until about 1850. After the abandonment of his furnace Anshutz accepted the management of John Probst's Westmoreland furnace, near Laughlinstown, and remained there about one year, whence he removed to Huntingdon county, where, in connection with Judge John Gloninger and Mordecai Massey, he built Huntingdon furnace i[illegible]rion, an[illegible] He died at Pittsburgh on February 28, 1837, aged[illegible]858 there we[illegible] three months.

Armstrong, six in Butler, twenty-seven in Clarion, and twenty-four in Venango—seventy-five in all. All of these were charcoal furnaces, except four coke furnaces at Brady's Bend. Many of these furnaces had, however, been abandoned at the latter date. Nearly every one has since then been abandoned. These furnaces were mainly built to supply the Pittsburgh rolling mills with pig iron.

There are now seventeen coke furnaces in this county, and their ag- [illegible] Brady's Bend, embracing

gregate production in 1883 was greater than that of any other pig-iron district in the United States, not excepting the celebrated Lehigh valley district in Pennsylvania.

The nail-cutting machines that were used about the beginning of the present century in Pennsylvania and for some years afterwards are doubtless correctly described in the following extract from the *History of Indiana County*, reference being made to a machine used in 1818 by a blacksmith in the town of Indiana, who is said to have manufactured all the cut nails that were used in Indiana county and in parts of Westmoreland, Armstrong, Jefferson, and Cambria counties.

> The machine used was propelled by one person using the right hand on one lever, and the right foot on another lever. The left hand was occupied in manipulating the iron from which the nails were cut. The iron was called "nail iron," and was of different widths, according to the requisite sizes desired, such as shingle, clapboard, brads, lathing, etc. Two-inch shingle nails were sold for 37½ cents per pound; clapboard do., 25 cents; brads, 18 cents; lathing, 31 cents, etc. Before cutting, the iron was brought to a red heat in the common blacksmith fire. After the nails were cooled they were taken to a place to be headed. This was done with a spring vise, which was closed by the pressure of the right foot. Only one nail was inserted at a time. One stroke of the hammer on the nail made a brad; two more made a clapboard or weather-boarding nail. The iron was procured at the different rolling mills in Huntingdon county, and hauled in wagons to Indiana county.

These nails were cut from plate iron that was rolled in the small rolling mills of the day and before the time when bar iron was rolled. To these small rolling mills were sometimes added slitters for slitting the flat strips of iron into nail-rods, which were converted into so-called wrought nails exclusively by hand, as we have elsewhere explained. The iron to be used in the early nail-cutting machines was first hammered to the thickness of about half an inch and then rolled to the width and thickness required by the sizes of the nails to be cut.

In 1810 there were in Pennsylvania forty-four blast furnaces, seventy-eight forges, four bloomaries, eighteen rolling and slitting mills, six air furnaces, fifty trip-hammers, five steel furnaces, and 175 naileries. The furnaces produced

26,878 tons of "cast iron"—the product of the whole country, with 153 blast and air furnaces, being 53,908 tons. Of the five steel furnaces in Pennsylvania one was in Philadelphia city and one in each of the counties of Philadelphia, Lancaster, Dauphin, and Fayette, and their product was 531 tons of steel, valued at $81,147. In 1840 there were 213 furnaces in Pennsylvania and 169 forges and rolling mills. In 1850 there were 298 furnaces, 121 forges, six bloomaries, and seventy-nine rolling mills. Of the furnaces existing in 1850 nearly all were charcoal furnaces, only fifty-seven being anthracite and eleven bituminous coal and coke furnaces. The production of the furnaces in 1849 was 253,035 tons; of the bloomaries, 335 tons; of the forges, 28,495 tons; and of the rolling mills, 108,358 tons.

The charcoal iron industry of Pennsylvania still exists in a healthy condition, but its glory has departed. About 1840 a revolution was created in the iron industry of the country by the introduction of bituminous and anthracite coal in the blast furnace, and since about 1850 the manufacture of charcoal iron in Pennsylvania furnaces has declined. About 1830 rolling mills in many parts of the State began to puddle iron extensively, and this innovation drove out of existence many charcoal forges which had been employed in producing blooms for rolling mills as well as to be reduced to bar iron under their own hammers. Most of the charcoal furnaces and forges and all of the charcoal bloomaries have been abandoned. The forges which yet remain are employed in the production of blooms for plate and sheet iron, boiler tubes, iron rods, and iron wire.

Since about the middle of the last century Pennsylvania, whose early iron history has unavoidably occupied so much of our space, has been the foremost iron-making State in the Union. In recent years it has produced one-half of all the pig iron, nearly one-half of all the rolled iron, and more than one-half of all the steel made in the United States.

CHAPTER XVII.

THE EARLY MANUFACTURE OF IRON IN DELAWARE.

IN the *Colonial Records of Pennsylvania*, volume I, page 115, mention is made of one James Bowle, "living near iron hill, about eight miles distance from New Castle," in Delaware, in 1684. In Oldmixon's *British Empire in America*, edition of 1708, in referring to New Castle county, then in Pennsylvania but now in Delaware, it is stated that there is a place in the county "called iron hill, from the iron ore found there," but the existence of an "iron mill," to use the ore, is expressly denied. This "iron hill" is undoubtedly the one referred to in the *Colonial Records* as having been discovered as early as 1684. Mrs. James says that on the 24th of September, 1717, Sir William Keith, Governor of Pennsylvania, "wrote to the Board of Trade in London that he had found great plenty of iron ore in Pennsylvania," and Bishop says that "Sir William Keith had iron works in New Castle county, Delaware, erected previous to 1730, and probably during his administration from 1717 to 1726." Emanuel Swedenborg, in his *De Ferro*, printed in 1734, gives some particulars of the early iron works in Delaware, which he doubtless derived from the Swedish settlers on the Delaware river. He mentions a furnace on the Christiana river, built by Sir William Keith about 1725, which produced large quantities of iron in the first two years of its existence, but was abandoned the next year owing to the difficulty of smelting the ore. He also mentions another furnace, about a mile distant from Sir William Keith's, which was not successful, and for which a bloomary was substituted. Another bloomary, near St. James's church, on the Huitleer river, (White Clay creek, or Red Clay creek,) is mentioned, the owner being John Ball. There is a local tradition that a furnace was in existence at the foot of "iron hill" about 1730. In the gable of an old Baptist church near "iron hill" is a cast-iron plate, dated 1746, which may have been cast at this furnace. In the edition of Oldmixon for 1741 the author says that "between Brandywine and Chris-

tiana is an iron mill." These references point out with all the exactness that is now possible the character and location and date of erection of the first iron enterprises in Delaware.

The iron hill to which reference has been made is situated about three miles south of Newark, near the Maryland line, and in sight of Christiana creek. Ore taken from this place has been used at Principio furnace, in Cecil county, Maryland, since 1847. This ore has also been used at some furnaces in Pennsylvania. Previous to 1847 the mines had been worked but little. Between 1832 and 1847 some ore was mined here and taken to a furnace in New Jersey.

Bishop says that in Sussex county, in the southern part of Delaware, "where bog ore in the shape of a very pure hydrate, yielding from 55 to 66 per cent. of iron, exists in large beds in the vicinity of Georgetown, and on the branches of the Nanticoke and Indian rivers, the manufacture of iron and castings was carried on before the Revolution to a considerable extent. The compact hydrated peroxide of some of these beds has, since the early part of this century, been raised in quantities for exportation, and the local production of iron is consequently less than it might have been." Tench Coxe, in his report on *The Arts and Manufactures of the United States* in 1810, mentions five forges in Sussex county, which produced in that year 215 tons of iron, but he makes no reference to a blast furnace in the whole State. About 1850 there was a forge in this county, known as Collins's forge, which made bar iron for the Baltimore and Philadelphia markets. Bog ore from near Milton, in Sussex county, was at one time taken to Millville, New Jersey, to be smelted in a furnace at that place which was built in 1815. Sussex ore has also been shipped to other places.

About 1820, as we were informed by Judge Caleb S. Layton, of Sussex county, in his lifetime, a blast furnace was established at Millsborough, on the Indian river, about eight miles south of Georgetown, by Colonel William D. Waples and others. In connection with this furnace was a foundry. An interest in the furnace was purchased in 1822 by Hon. Samuel G. Wright, of New Jersey, and in 1830 his son, Colonel Gardiner H. Wright, obtained an interest, and afterwards operated the furnace until 1836, when it went out of blast

finally. The foundry continued in operation until 1879. In 1859 Lesley stated that "Millsborough charcoal furnace, owned by Gardiner H. Wright, of Millsborough, Sussex county, Delaware, is the only furnace in the State, and has not made iron for ten years. A cupola furnace is in activity beside it." Francis Vincent, of Wilmington, informs us that the castings for the Eastern Penitentiary of Pennsylvania, and for Moyamensing Prison, and the iron railing which once surrounded Independence Square, in Philadelphia, were cast at Millsborough furnace—we presume at the "cupola furnace." He also informs us that ten or twelve years before the Revolution an English company, under the leadership of Colonel Joseph Vaughan, built a furnace near Concord, in Sussex county. The company had a stone wharf at the head of Nanticoke river, and shipped its iron direct to England. The iron was called "Old Meadow." "The stone wharf is there yet," says Mr. Vincent. Colonel Vaughan commanded one of the Delaware regiments during the Revolution. In 1828 and in the two succeeding years Millsborough furnace and foundry produced 450 tons of pig iron and 350 tons of castings.

A rolling mill near Wilmington, in Delaware, existing and in operation in 1787 or 1788, has already been referred to in the chapter relating to New York. This mill then rolled Swedish and Russian iron for the use of a New York cut-nail factory. Tench Coxe says that in 1810 there were three rolling and slitting mills in New Castle county. Lesley stated in 1859 that the Delaware iron works, located five miles northwest of Wilmington, owned by Alan Wood, of Philadelphia, and built in 1812, "began to manufacture sheet iron thirty years ago in what had been a nail-plate works. At that time only Townsend in New Jersey made sheet iron." Marshall's rolling mill, on Red Clay creek, two miles west of Newport, was built in 1836 by Caleb and John Marshall, to roll sheet iron. The Wilmington rolling mill, near Wilmington, was built in 1846. The Diamond State rolling mill, at Wilmington, was built in 1854. These were the only rolling mills existing in Delaware in 1859. Others have since been built. The business of iron shipbuilding has been added to the iron industries of Delaware within the last few years. There is now neither a blast furnace nor a forge in the State.

CHAPTER XVIII.

EARLY IRON ENTERPRISES IN MARYLAND.

In his *Report on the Manufacture of Iron*, addressed to the Governor of Maryland in 1840, Alexander gives 1715 as "the epoch of *furnaces* in Maryland, Virginia, and Pennsylvania." This statement is not accurate except in regard to Virginia. Maryland probably had no iron enterprises but a bloomary or two until 1724. Scrivenor says that in 1718 "Maryland and Virginia" exported to England 3 tons and 7 cwt. of bar iron, upon which the mother country collected a duty of £6 19s. 1d. This bar iron could only have been made in Maryland, as Virginia had no forges at this time. In 1719 the general assembly of Maryland passed an act "authorizing 100 acres of land to be laid off to any who would set up furnaces and forges in the province." Other inducements were offered in 1721 and subsequently to those who would engage in the manufacture of iron. The preamble to the act of 1719 recites that "there are very great conveniences of carrying on iron works within this province, which have not hitherto been embraced for want of proper encouragement to *some first undertakers*," which clearly implies that iron enterprises had already been undertaken in Maryland but were not then in operation. As a result of the encouragement given by the general assembly, authentic reports show that in 1749 and again in 1756 there were eight furnaces and nine forges in Maryland, and that on the 21st of December, 1761, there were eight furnaces, making about 2,500 tons of pig iron annually, and ten forges, capable of making about 600 tons of bar iron annually. During the colonial period Maryland had no manufacturing industry worthy of the name except that of iron. Tobacco-growing and wheat-growing formed the principal employments of the people.

The first iron works in Maryland were probably erected in Cecil county, at the head of Chesapeake bay. We suppose that a bloomary at North East, on North East river, erected previous to 1716, formed the pioneer iron enterprise.

That iron works were built at North East previous to 1716 is proved by a deed, dated in that year, in which Robert Dutton conveyed a flour mill near the "bottom of the main falls of North East," together with fifty acres of land, to Richard Bennett for £100 in silver money. In this deed "iron works" are mentioned as among the appurtenances which were conveyed by it. We quote from Johnston's *History of Cecil County.* These works could have embraced only a bloomary, as there was not at this time a blast furnace, to supply them with pig iron, either in Maryland or Pennsylvania. They were probably not then active.

A short time before the passage of the act of 1719, above alluded to, Joseph Farmer, an ironmaster, of England, came to Maryland in behalf of himself and other adventurers in the manufacture of iron. Whether he was interested in the works at North East, or not, can not now be learned. About 1721 he commenced the erection of a furnace on Talbot's manor, in Cecil county, near the mouth of Principio creek, which empties into Chesapeake bay near the mouth of the Susquehanna river and about six miles from the town of North East. The names of all of Farmer's associates at this time can not be ascertained, but William Russell, an ironmaster of Birmingham, England, was undoubtedly one of them. The company was at first styled Joseph Farmer & Company, but was afterwards styled the Principio Company. After having made some progress in the erection of the furnace, Farmer returned to England, probably early in 1722, leaving the enterprise in charge of Stephen Onion as its general manager. A son of Joshua Gee, and also Thomas Russell, a son of William Russell, were at Principio at this time.

About the beginning of 1723 the company decided to put John England in immediate charge of its Principio enterprise, with entire control of it, superseding Stephen Onion. The company at this time was composed of William Chetwynd, of Grindon, in Warwickshire, a gentleman of wealth and position; Joshua Gee, a merchant of London; William Russell, an ironmaster of Birmingham; John England, an ironmaster of Staffordshire; John Ruston, and Joseph Farmer. It is very clear that the company had been enlarged, as the result of glowing representations made by Farmer.

Several of the members, including Joshua Gee and John England, were Friends, or Quakers. William Chetwynd was the leading capitalist of the company, and he was also the special friend of John England.

In April, 1723, John England and his wife, (who died at Principio during this year,) sailed for Philadelphia, which place they reached after a passage of seven weeks and one day. A few days afterwards they arrived at Principio. Prior to this time Joseph England, a brother of John England, was engaged at Principio, probably in building the furnace. On the 25th of June (old style) John England wrote to Joseph Farmer a long letter of complaint concerning the condition in which he found the affairs of the company at Principio. He says: "When I came I found I think everything contrary to my expectations on thy information; for as to y^e^ furnace, which, according to thy information when at London, was very near ready to blow, is but 18 inches above y^e^ second couplings, and y^e^ inner wall is but 6 feet high. . . . Neither did I think thee wouldest have been guilty of ordering a furnace to have been built until thee hadst been sure of mine, that which was good and enough of it for perpetuity; for I have been at Patapsco, Bush river, and North East, and seen all y^e^ mine along shore in every place, and can not find any more than will serve for one blast, if that. . . . And when I treated with thee I feared interest was in y^e^ bottom, which now I find true. . . . As to stock of both cole and mine, there may be about two months' stock in of both cole and mine, and when there will be a stock for a blast I can not tell, cole lying three miles from y^e^ furnace and stone at such a distance. . . . You may assure yourselves here hath been and is such ruin as I never saw." The letter was intended to be seen by the other members of the company. The writer dwelt at length upon the unhealthiness of Principio and the inefficiency, drunkenness, and mutinous temper of the workmen, many of whom appear to have been convicts from England, while others were "redemptioners" from various European countries. After admitting that his disgust was at first so great that he had thought of immediately returning to England, he adds: "I concluded to stay and set up a little forge to try y^e^ iron if ever y^e^ furnace runs any mettle."

These extracts show some of the difficulties which beset John England at the beginning of his experience at Principio. Subsequent letters from him to various members of the company are largely devoted to the narration of other difficulties with which he had to contend, chief of which was the financial and other demoralization produced by the mismanagement of the company's affairs by Stephen Onion. At the close of the year Onion, who had been retained as a clerk, was dismissed, and after that event Mr. England appears to have had less trouble. In 1724 Stephen Onion and Thomas Russell sailed from New Castle for Great Britain, in the same ship with Benjamin Franklin, who says in his autobiography that they were "masters of an iron work in Maryland" and had engaged "the great cabin." Franklin would of course not receive from Onion a true account of the situation at Principio.

Stephen Onion had made false representations in 1722 of the progress that had been made in building the furnace. On the 11th of August of that year he wrote to the company as follows: "We hope we shall finish the stack of the furnace, casting-house, and bridge ditto in a month more. The collyers are at work, and hope to have in by Christmas 400 load of cole." Of the actual progress made in building the furnace down to John England's arrival in 1723 we have already been informed in that gentleman's letters.

On September 12, 1723, John England wrote to Joshua Gee as follows: "I have been at a bloomary with some of our mine, and it maketh very good iron, and iron taketh a very good price here, £40 per ton, and hath done for several years past." Where this bloomary was located we can not discover, nor by whom it was owned, but it can easily be conjectured that it was at North East, where there were "iron works" as early as 1716, as has already been stated.

On January 13, 1724, Mr. England wrote to Joshua Gee that he was "going on with y^e^ forge dam and race to bring water to y^e^ forge." In the same month he wrote to Joseph Farmer concerning the bellows for the chafery and finery, which he desired to have made in England. On the 2d of April, 1724, he wrote to Joshua Gee that he had heard of "mine" near Annapolis, which he was going to see. In the

same month he wrote to William Russell that "y^e^ furnace might have blowed some time since, but did not think it proper so to do without a better stock of cole and mine upon y^e^ bank;" also that the company's sloop was then employed "in fetching shells to burn for lime to build a great stone wall for y^e^ fore bay of y^e^ forge," and that other preparations for building the forge and its accessories were then actively in progress. In both letters the hope was expressed that there would soon be a sufficient supply of charcoal to keep the furnace in blast for some time, "if we can but get mine." Mr. England was continually apprehensive of a scarcity of iron ore of good quality, which he had not found in abundance in the neighborhood of the furnace, but for which he sought diligently in other places.

We do not hear again of the Principio works until September 15, 1725, when William and Walter Chetwynd, John Wightwick, William Russell, and Thomas Russell write to Mr. England from Grindon a long and very important letter, beginning, "We that sign are met together at Grindon," and conveying to Mr. England "full and absolute power over all persons employed in America in our service," and also "full power to act in all things with y^e^ authority as we ourselves were we on y^e^ spot." This fresh expression of confidence and fresh grant of authority had a special object in view, as we shall presently see, but we are now interested in learning from this letter that "our furnace and forge in Maryland" were finished when it was written. We presume that the furnace was put in blast in 1724 and that the forge was started in 1725. The letter says: "We hear you have a good stock of pigs on y^e^ bank, therefore desire you not to fail sending us by y^e^ first shipping what pigs you can spare over and above what can be worked up at y^e^ forge till y^e^ furnace goes again, which we hope may be between 3 and 400 tons; for tho y^e^ forge should be worked double hand, which we intend it shall, it will hardly work up above 8 tons of pigs per week, and to have y^e^ overplus of y^e^ pigs lying dead will be great loss to y^e^ company." This extract would seem to indicate that the furnace had finished its first blast and was then idle. It was certainly in blast as early as May 9, 1725, on which date Joseph Growdon, of Bensalem, ordered a "hammer, anvil,

and other iron work necessary for one single bloomary" to be cast at the furnace, Mr. Growdon having found iron ore on his land. At this time the British duty on pig iron from the colonies was four shillings per ton. Reference is made in the letter to "two finers and hammermen" who had been sent by the company to work at the forge, and others were promised "in a short time." Mr. England is advised to "sell all ye iron you make at ye forge at Principio" in American markets instead of sending it to England to be sold. Stephen Onion appears to have had sufficient address to secure from the company his partial restoration to favor, as the letter advises Mr. England that he had been appointed clerk of the furnace and forge, but subject wholly to Mr. England's authority, who is expressly told that he can discharge him if he does not give satisfaction.

It will be observed from the names of the signers of the above letter that the *personnel* of the Principio Company had undergone some changes. In a letter from William Chetwynd to John England, dated September 19th, he refers to the signers of the above letter as "all ye company except Mr. Gee," who was not wanted but could not be shaken off. In subsequent years other names are added to the company.

We now come to consider the particular object which the company had in view in writing the letter of the 15th of September to Mr. England. It appears that Mr. England, in his search for iron ore, had found valuable deposits of ore on the land of Captain Augustine Washington, on the north side of the Rappahannock river, in Virginia. This Captain Washington was the father of George Washington. Mr. England had been so favorably impressed with the value of the ore on Captain Washington's land, and with the other advantages which the location offered for the manufacture of iron, that he had contracted with that gentleman in the name of the company to erect a furnace upon his land, Captain Washington to have an interest in its ownership. The letter of the 15th of September from the company heartily approved of this action by Mr. England, authorized him to buy negroes and go on with the project, and made a division of the shares of ownership in the new venture. If Mr. Gee could be dropped from the company the shares were to be as follows: Captain

Washington, two-twelfths; John Wightwick, one-twelfth; William Russell, one-twelfth; Thomas Russell, one-twelfth; Walter and William Chetwynd, five-twelfths, and John England, two-twelfths. But if Mr. Gee could not be dropped then the shares were to be divided as follows: Captain Washington, two-twelfths; John Wightwick, one-twelfth; William Russell, one-twelfth; Thomas Russell, one-twelfth; Walter Chetwynd, two-twelfths; William Chetwynd, two-twelfths; Joshua Gee, two-twelfths, and John England, one-twelfth. Mr. Gee remained a member of the company. Mr. England at once proceeded with the erection of a furnace on Captain Washington's land, and so actively did he prosecute the work that the furnace was ready to be blown in in February, 1726, and John Barker, the founder at Principio, was deputed to blow it in. This was Accokeek furnace, about which we shall have something further to say in a subsequent chapter devoted to Virginia. It was long known as "England's iron works." The clerk at Accokeek furnace when it was built was Ralph Falkner, but as early as 1730 Nathaniel Chapman was the clerk.

In 1730 John England was still in charge of all the company's iron enterprises in this country, including an abandoned project on James river which had not been given tangible shape. Stephen Onion was still the clerk at Principio, but the company was annoyed at his failure to settle his accounts. The Principio furnace and forge and the Accokeek furnace were in operation in this year. At this time we hear nothing of a forge at North East. In 1726 Mr. England purchased for himself a large tract of land on White Clay creek, in New Castle county, Delaware. About the time he purchased this estate he also purchased conditionally from Sir William Keith "sundry lands and tenements in New Castle county, on Dellaware, upon which lands there was a small iron forge and supposed to be a great quantity of iron ore." It was John England's intention to erect upon this land "works for carrying on the making of pigg and barr iron if a sufficient quantity of iron ore or mine could be found on yᵉ land." This project was abandoned owing to the lack of ore, and we hear no more of John England until his death in 1734. He was one of the most intelligent, enterprising, and successful

of early American ironmasters. The various works of the Principio Company, of which he was so efficient an agent, were in the very front rank of our colonial iron enterprises.

We are unable to glean any further particulars about the first works at North East than have already been given, but in an inventory of the possessions of the Principio Company in May, 1723, there is an entry which probably refers to them. This entry credits the company with the purchase, on July 9, 1722, of 383 acres of land "in Lord Baltimore's Mannor of North East, called Vulcan's Tryal, Vulcan's Enlargement, and Diffidence." This purchase may have embraced the North East "iron works," upon the site of which, at the "bottom of the main falls of North East," the company subsequently erected a new forge, probably about 1735. It was in operation and briskly employed in 1743. The first entry in the inventory mentions the purchase on October 14, 1721, of 8,110 acres of land called Gee Faruson, near North East. It is exceedingly probable that Joseph Farmer and his associates made investments at North East preliminary to the manufacture of iron at that place before they decided to build the furnace at Principio.

For the facts contained in the foregoing very full and absolutely accurate history of the commencement of the Principio iron works we are mainly indebted to the courtesy of James B. England, Esq., of Philadelphia, a descendant of Joseph England, who has placed in our hands the original correspondence between John England and the Principio Company.

In Emanuel Swedenborg's *De Ferro*, published in 1734, we find at the beginning of an account of iron works "in Maryland and Pennsylvania in the West Indies" the following reference to the Principio works: "There are several furnaces for the smelting of iron ore, as well as works for the smelting of raw iron, not so very long since built. The principal work is called Principio, in the upper part of the province of Maryland, upon the river called Principio, from which it also derives the name; its water is said to fall from a height of 25 feet. At this iron work little two-oared boats and little ships land laden with iron ore, which is dug 50 miles from there. The ore is said to be of a gray color, not unlike the

figured vessels of Holland, containing 50 per cent. of iron. The iron from this ore is said to carry off the palm from the rest."

We obtain additional information concerning the famous Principio iron works from a valuable historical essay prepared several years ago by Mr. Henry Whiteley, of Philadelphia, which we give on this page and the following page.

Ore for Principio furnace was at first obtained in the immediate neighborhood, but as early as September 4, 1724, it was obtained from Gorsuch's Point, below Canton, on the eastern shore of the Patapsco, about opposite to Fort McHenry. In 1727 the Principio Company, through John England, purchased all the iron ore, "opened and discovered, or shut and not yet discovered," on Whetstone Point, at the extremity of which Fort McHenry now stands, for £300 sterling and £20 current money of Maryland. This was for many years one of its principal sources of ore supply.

Kingsbury furnace was the next furnace of the company after Accokeek. It was situated on Herring run, at the head of Back river, in Baltimore county. It was built in 1744 and went into blast in April, 1745, producing at the first blast, which lasted till December 18th of the same year, 480 tons of pig iron. The first four blasts embraced the period extending from April 1, 1745, to December 26, 1751, and produced 3,853 tons, or an average of 75 tons per working month. More than 3,300 tons of the iron were shipped to the company in England. In 1751 Lancashire furnace was purchased from Dr. Charles Carroll, of Annapolis. It was located near Kingsbury, on the west side of a branch of Back river, a few miles northeast of Baltimore. The deed embraced 8,200 acres of land, and was "signed" on behalf of the company by Lawrence Washington. Lancashire furnace was operated by the company from the time of its purchase until the Revolution. It was its last acquisition of property in America. At the time of its purchase the company outranked all competitors, being the sole proprietor of four furnaces and two forges, viz.: Principio furnace, Cecil county, Maryland, built in 1724; Principio forge at the same place; North East forge, Cecil county, Maryland, built about 1735; Accokeek furnace, Virginia, built in 1726; Kingsbury furnace, Baltimore county, Maryland,

built in 1744; Lancashire furnace, Baltimore county, Maryland, purchased in 1751. The company owned slaves and live stock in abundance, and its landed estates were of great extent, amounting to nearly thirty thousand acres, exclusive of the Accokeek lands in Virginia. One-half of the pig iron exported to Great Britain from this country before the Revolution is said by Mr. Whiteley to have come from its works.

After 1776 the company had no actual control over any of its American property. Thomas Russell, who had been the company's general manager, continued to operate the furnaces and forges, and supplied bar iron and cannon balls in large quantities to the Continental army. In the Lancashire furnace ledger is an "account of shott made at Lancashire furnace in the year 1776."

In 1780 the general assembly of Maryland passed an act to seize and confiscate all British property within the State, and this was the formal end of the Principio Company, after an existence of more than sixty years. All the property of the company, with two exceptions, passed under the auctioneer's hammer and into new hands. The works at North East were retained by Thomas Russell, one of the company and a son of the first Thomas Russell, who had cast his fortunes with the patriotic cause. "A certain Mr. Washington" owned a one-twelfth interest in the possessions of the company, and was also an adherent of the patriotic cause. What action was taken by Virginia concerning the possessions of the company in that State we are not advised, but Mr. Washington's interest in them and in the company's Maryland possessions could not be confiscated.

Thomas Russell, at his death in 1786, left a son Thomas, the third of that name. On his arrival at the age of twenty-one, his mother having previously married Daniel Sheredine, he revived the iron industry at North East, with the assistance of Sheredine, and built, in 1802, a furnace which was in operation only four years. Not proving as profitable as had been anticipated, it was blown out on the death of young Thomas Russell, which occurred in 1806. Thenceforward the various iron works at North East met with many vicissitudes until they fell into the hands of the present enterprising owners.—We need not quote further from Mr. Whiteley's essay.

Alexander says that a part of the hearth of the original Principio furnace was still standing in 1840, when his report was written. The same excellent authority says that on February 5, 1734, (old style,) in pursuance of the act of 1719, already referred to, a precept for 100 acres of land on North East river, forming part of North East manor, was issued to John Ruston, who had been one of the members of the Principio Company; and he further says that on August 31, 1736, this tract was assigned to William Chetwynd, of Beddington, in Surrey, England. (He was probably William Chetwynd, of Grindon.) It was about this time that the company built its forge at North East. Alexander says that this forge was in his day "commonly called Russell's forge," reference being made to the last Russell who was connected with it.

In 1744 William Black, secretary of the commissioners who were appointed by Governor Gooch, of Virginia, to unite with those from Pennsylvania and Maryland to treat with the Iroquois, or Six Nations of Indians, in reference to the lands west of the Alleghenies, wrote in his journal, on May 25th, while at North East, in Maryland: "I must not forget that in the forenoone the Com'rs and their company went to the Principio iron works, in order to view the curiosities of that place. They are under the management of Mr. Baxter, a Virginian, and was at work forming barr-iron when we came there. For my part I was no judge of the workmanship, but I thought everything appeared to be in very good order, and they are allowed to be as compleat works as any on the continent by those who are judges." This visit was probably made to the forge at North East. The furnace and forge at Principio were also, however, both in operation in that year.

Iron works have been almost continuously in operation at Principio and North East since their first establishment, or for about one hundred and sixty years. At Principio George P. Whitaker and his associates have had a charcoal furnace in operation since 1837, near the site of the first Principio furnace; and at North East, on the very site of the forge built by the Principio Company about 1735, are the present extensive iron works of the McCullough Iron Company, including probably the largest forge in the United States for the production of blooms from pig iron.

Pig iron from Virginia furnaces near tidewater was taken to Principio forge, and also to the forge at North East, to be refined into bar iron.

About thirty years ago a whole pig of iron was found near the site of the first Principio furnace, which was plainly stamped "Principio, 1727." A few years ago two or three pigs of iron, marked "Principio, 1751," were discovered in the bed of the Patapsco river. All of these relics have been preserved.

A furnace at the mouth of Gwynn's falls, and a forge called Mount Royal, at Jones's falls, were built by the Baltimore Company soon after 1723 and before 1730—Messrs. Carroll, Tasker, and others forming the company.

Stephen Onion severed his connection with the Principio Company and built a furnace and two forges of his own at the head of Gunpowder river, about a mile from Joppa, then one of the principal towns of Maryland, but now wholly deserted. These works were advertised for sale in 1769, after Stephen Onion's death. The exact date of their erection has not been preserved.

Bush furnace, in Harford county, and Northampton furnace, in Baltimore county, were built about 1760, the latter by members of the Ridgely family. The proprietors of this furnace owned a forge on the Great Gunpowder river, called Long Cam forge, which was probably older than the furnace. Bush furnace, located on Bush creek, was owned about 1767 by John Lee Webster. On the Patapsco, near Elkridge Landing, were Elkridge furnace and forge, owned by Edward Dorsey; at a locality not now known was York furnace; in Anne Arundel county were the Patuxent furnace and forge, owned by Thomas, Richard, and Edward Snowden. Richard Snowden was the proprietor of "iron works" on the eastern branch of the Patuxent as early as 1734. There was an early furnace on Stemmer's run, about seven miles from Baltimore. There was also a furnace on Curtis creek, in Patapsco county, built by William Goodwin and Edward Dorsey, which remained in operation until 1851. Nottingham furnace, in Baltimore, was built before the Revolution.

In 1762 Robert Evans, Jonathan Morris, and Benjamin Jacobs built Unicorn forge at a place called Nasby, in Queen

Anne county. The castings for the forge were procured at "Bush river furnace," which appears to have been then operated by Isaac Webster. The firm of Evans, Morris & Jacobs was not long in existence.

In Frederick county were several early iron enterprises, particulars of which have been preserved by Alexander. Old Hampton furnace, on Tom's creek, about two miles west of Emmetsburg, was built between 1760 and 1765 by persons whose names have not survived. Legh furnace was built about the same time by an Englishman named Legh Master, at the head of Little Pipe creek, two or three miles southwest of Westminster. Both of these furnaces were soon abandoned. Catoctin furnace, situated about twelve miles northwest of Frederick, was built in 1774 by James Johnson & Co. It was rebuilt in 1787 by the same company, "about three-fourths of a mile further up Little Hunting creek, and nearer the ore banks." It was again rebuilt about 1831. This furnace and two later furnaces of the same name were in blast in 1880. The original Catoctin furnace yielded at first from twelve to eighteen tons of pig iron weekly. Shortly after its erection the same owners erected on Bush creek, about two miles above its mouth, the Bush Creek forge, which was in operation until 1810, when it was abandoned. About the time when Catoctin furnace and Bush Creek forge were built the Johnsons built a rolling and slitting mill at a spot known in 1840 as Reel's mill. About 1787 they built Johnson furnace on a small stream one mile above the mouth of the Monocacy. In 1793 the various iron properties belonging to the Johnsons were divided, and Johnson furnace fell to Roger Johnson, who soon afterwards built a forge in connection with the furnace. It was situated on Big Bennett's creek, about five miles above its junction with the Monocacy, and was called Bloomsburg forge. Its weekly product was between four and five tons of finished iron. The furnace and forge were abandoned soon after 1800. Fielderea furnace, on the Harper's Ferry road, three miles south of Frederick, was built by Fielder Gantt soon after the Revolution, but after making one blast it was abandoned. This event occurred before 1791.

In Washington county there were many iron enterprises at an early day, most of which have been noted by Alexander.

In 1770 James Johnson superintended the erection of Green Spring furnace, on Green Spring run, one mile above its entrance into the Potomac. It was owned by a Mr. Jacques and Governor Johnson. The neighboring iron ore not being of good quality, the furnace was abandoned in a few years. James Johnson also built Licking Creek forge, near the mouth of Licking creek, for the same firm. It was at first supplied with pig iron from Green Spring furnace, but was afterwards sold to "Mr. Chambers, of Chambersburg, who carried it on for several years with pig supplied from his furnace in Pennsylvania." Mount Etna furnace, on a branch of Antietam creek, five or six miles north of Hagerstown, was built by Samuel and Daniel Hughes about 1770, and was in successful operation for many years. During the Revolution it cast the first Maryland cannon. About a mile and a half from the furnace, and about four miles from Hagerstown, the same owners built Antietam forge, which was in operation after the furnace was abandoned. Bishop states that General Thomas Johnson and his brother were the owners in May, 1777, of a furnace at Frederick, but it was not then in blast. Between 1775 and 1780 Henderson & Ross built a furnace at the mouth of Antietam creek. A forge was built at the same place about the same time. There were at least three forges on Antietam creek during the last century. In 1845 a new furnace was built on the site of the original Antietam furnace, and it is still in operation. A small rolling mill, with a nail factory attached, was built at the same place about 1831 and abandoned about 1853.

Bishop says that a slitting mill was established at or near Baltimore in 1778 by William Whetcroft, and that about the same time two nail factories were established in the city—one by George Matthews and the other by Richardson Stewart. At Elkridge Landing Dr. Howard owned a tilting forge in 1783. On Deer creek, in Harford county, a forge and slitting mill were built during the last century. During the Revolution there were seventeen or eighteen forges in operation in Maryland, in addition to furnaces and other iron enterprises.

After the Revolution the iron manufacture of Maryland experienced a healthy development, which continued without serious interruption until in recent years. One of the

most successful rolling mills in the State was the celebrated Avalon iron works, on the Baltimore and Ohio Railroad, half a mile from the Relay House, "built by the Dorseys" about 1795, and in use down to about 1860. It first made nails and bar iron, and in its latter days large quantities of both, but afterwards, before 1850, it also rolled rails. A rolling mill was built on the Big Elk river, five miles north of Elkton, in 1810, on the site of copper works which had existed before the Revolution. It was active until about 1860, making sheet iron chiefly. Octorara forge and rolling mill, on Octorara creek, four miles above its mouth and eight miles north of Port Deposit, were built about 1810. These works are still active, and, together with two other Maryland rolling mills of modern origin, are owned by the McCullough Iron Company. The once numerous forges of Maryland have gradually given place to rolling mills. In 1840 several forges were in operation; in 1856 two forges were active, and in 1880 there was only one forge active, the one at North East.

The development of the iron ores belonging to the coal measures of the extreme western part of Maryland appears to have been undertaken about fifty years ago. Near the village of Friendsville, on Bear creek, a branch of the Youghiogheny river, there were erected, in 1828 and 1829, the Yohogany iron works, consisting of a furnace and two forges, to use charcoal. These works were abandoned about 1834. In 1837 a furnace fifty feet high and fourteen and one-half feet wide at the boshes was built at Lonaconing, eight miles southwest of Frostburg, by the George's Creek Coal and Iron Company, to use coke. In June, 1839, it was making about seventy tons of good foundry iron per week, with coke as fuel. Overman claims that this was the first successful coke furnace in the United States. Two large blast furnaces were built in 1840 by the Mount Savage Iron Company, nine miles northwest of Cumberland, also to use coke. This enterprise was also successful. In 1845 the same company built an additional furnace, but it was never lined. The Mount Savage rolling mill was built in 1843, especially to roll iron rails, and in 1844 it rolled the first rails rolled in this country. These rails were of the inverted U pattern, and weighed forty-two pounds to the yard. Alleghany county, Maryland, is thus entitled to

two of the highest honors in connection with the American iron trade. It built the first successful coke furnace and rolled the first heavy iron rails. The furnaces and rolling mill of the Mount Savage Iron Company have long been abandoned.

In 1846 a furnace called Lena was built at Cumberland, which at first used charcoal and afterwards used coke. It was not long in operation.

Alexander mentions a furnace on the Eastern Shore of Maryland, built in 1830 by Mark Richards, about five miles from Snow Hill, to use bog ore yielding only 28 per cent. of iron. Its annual production about 1834 was 700 tons. In 1840 the furnace was owned by T. A. Spence. It was called Naseongo, and it was the only furnace in the State that used bog ore exclusively or in large quantities. A bloomary which used bog ore once stood near Federalsburg, but it was abandoned long ago.

The prominence of Maryland as an iron-producing State was relatively much greater in 1870 than in 1880. In the former year it was fifth in rank, but in the latter year it was only twelfth in rank.

A FURNACE was built at Georgetown, in the District of Columbia, in 1849, and went out of blast finally about 1855. A second stack was built at the same place, but was never lined, and consequently was never put in blast. Both of these were small furnaces. The furnace which was in operation used charcoal and was blown with steam-power. Both furnaces were owned by William A. Bradley, of Washington. Before 1812 the United States Government built an anchor forge at the navy-yard at Washington, which was enlarged about 1830, and afterwards used to produce anchors, shafts, chains, etc. About the time when this forge was established there was a cannon foundry "about a mile beyond Georgetown, on the Potomac river." "A cannon was cast at this foundry of 100 lbs. ball, to which was given the name of Columbiad." The District of Columbia had no other iron enterprises until 1878, when the Government established a small rolling mill at the navy-yard. The forge is still in operation, and so also is the rolling mill.

CHAPTER XIX.

REVIVAL OF THE IRON INDUSTRY IN VIRGINIA.

After the failure to manufacture iron on Falling creek in 1622 no successful effort was made to revive the iron industry in Virginia until after the beginning of the succeeding century—a delay of almost a hundred years. To Colonel Alexander Spotswood, who was Governor of Virginia from 1710 to 1723, the honor of having established the iron industry of the colony on a firm and permanent basis is fairly due, although the exact date of the commencement of his various iron enterprises is lost. We are indebted to the researches of R. A. Brock, Esq., of Richmond, for the following information concerning the inception of Governor Spotswood's schemes to effect a revival of the iron industry in Virginia.

In the collections of the Virginia Historical Society are two MS. volumes of the letters of Governor Spotswood to the lords commissioners the council of trade at London, covering the period from 1710 to 1721. On October 24, 1710, the Governor writes: "There is a project to be handed to the next assembly for improvement of the iron mines, lately discovered in this country, the ores of which upon tryall have been found to be extraordinary rich and good. It is proposed that the work be carried on at publick charge." This scheme appears not to have been acted upon by the assembly. On December 15, 1710, the Governor writes: "I humbly propose to your lordships' consideration whether it might not turn to good account if her majesty would be pleased to take that work [the iron] in her own hands, sending over workmen and materials for carrying it on." He states that the "iron mines lie at the falls of James river." On January 27, 1714, he asks that the German Protestants settled at the head of the Rappahannock river, who came over with Baron de Graffenreidt "in hopes to find out mines," be exempted from the payment of levies for the support of the government. In the latter part of 1716 elaborate charges of malfeasance in office were anonymously preferred against Governor Spotswood to

the council of trade, the counts of which are numerous. In one of them Governor Spotswood is charged, under pretense of guarding the frontiers, with building, at the cost of the government, two forts, one at the head of James river and another at the head of Rappahannock river, only to support his two private interests, at least one of which, that on the Rappahannock, related to the manufacture of iron. Another account charges the maintenance at public cost, at these forts, of a corps of "rangers," for three years ending in December, 1716. The beginning of this period would be near that of the German settlement, the members of which were the operatives of Governor Spotswood. It may be assumed that some of his iron enterprises were in operation certainly in 1716, and most likely two years earlier.

In 1727 the general assembly of Virginia passed "an act for encouraging adventurers in iron works," which begins as follows: "Whereas, divers persons have of late expended great sums of money in erecting furnaces and other works for the making of iron in several parts of the country, . . . and forasmuch as it is absolutely necessary for roads to be laid out and cleaned from all such iron works to convenient landings," etc.

In *A Progress to the Mines,* by Colonel William Byrd, of Westover, Virginia, written in September, 1732, is given a full account of the iron enterprises of Virginia at that time. They embraced three blast furnaces and one air furnace, but no forge. One of the blast furnaces was at Fredericksville, a village which has disappeared from the maps, but which was located about twenty-five miles south of Fredericksburg, in either Caroline or Spottsylvania county. Mr. Chiswell, the manager, told Colonel Byrd that the pig iron produced at the furnace was carted twenty-four miles over an uneven road to the Rappahannock river, about a mile below Fredericksburg. This furnace was built of brick, but it had been idle "ever since May, for want of corn to support the cattle." Colonel Byrd says: "The fire in the furnace is blown by two mighty pair of bellows, that cost £100 each, and these bellows are moved by a great wheel of twenty-six foot diameter." The owners of the furnace had invested about £12,000 in land, negroes, cattle, etc., and had made 1,200 tons of iron. "When

the furnace blows it runs about twenty tons a week." Colonel Byrd says the company was formed as follows: "Mr. Fitz Williams took up the mine tract, and had the address to draw in the Governor, [Spotswood,] Captain Pearse, Dr. Nicolas, and Mr. Chiswell to be jointly concerned with him, by which contrivance he first got a good price for the land, and then, when he had been very little out of pocket, sold his share to Mr. Nelson for £500, and of these gentlemen the company at present consists. And Mr. Chiswell is the only person amongst them that knows anything of the matter." One of the mines attached to the furnace was fifteen or twenty feet deep, and the ore was dislodged by blasting, after which it was carried away "in baskets up to the heap." It was calcined before being used, layers of charcoal and ore alternating. The limestone used at the furnace was brought from Bristol as ballast, and carted from the Rappahannock to the furnace by the ox teams which brought down the iron. Colonel Byrd recommended the substitution of oyster shells for limestone, but without effect.

The next furnace visited by Colonel Byrd was directly controlled by Colonel Spotswood, and was situated in Spottsylvania county, about twenty miles southwest of Fredericksburg, and about thirteen miles from Germanna. This last place was situated in Orange county, on the south side of the Rapidan, and about fourteen miles distant from its junction with the Rappahannock. It had been settled by Germans and afterwards abandoned for another location on "land of their own, ten miles higher, in the Fork of Rappahannock." This furnace, according to Colonel Spotswood, was the first in Virginia. It was built of rough stone, "having been the first of that kind erected in the country." The iron made at this furnace was carted fifteen miles to Massaponux, on the Rappahannock, five miles above Fredericksburg, where Colonel Spotswood had recently erected an air furnace, which he "had now brought to perfection, and should be thereby able to furnish the whole country with all sorts of cast iron, as cheap and as good as ever came from England." The blast furnace "had not blown for several moons, the Colonel having taken off great part of his people to carry on his air furnace at Massaponux." "Here the wheel that carried the bellows was

no more than twenty feet diameter." The ore at this furnace was also blasted with gunpowder. "All the land hereabouts seems paved with iron ore, so that there seems to be enough to feed a furnace for many ages."

Colonel Byrd next mentions "England's iron mines, called so from the chief manager of them, tho' the land belongs to Mr. Washington." These mines he states were on the north side of the Rappahannock river, "not far from a spring of strong steel water," which was in King George county, twelve miles distant from Fredericksburg. Two miles distant from the mines was a furnace. "Mr. Washington raises the ore, and carts it thither for twenty shillings the ton of iron that it yields. The furnace is built on a run, which discharges its waters into Potomeck. And when the iron is cast they cart it about six miles to a landing on that river. Besides Mr. Washington and Mr. England there are several other persons in England concerned in these works. Matters are very well managed there, and no expense is spared to make them profitable, which is not the case in the works I have already mentioned." This was Accokeek furnace, already referred to in the Maryland chapter as forming one of the possessions of the Principio Company. It was situated in Stafford county. The "Mr. Washington" referred to was Augustine Washington, the father of George Washington.

Colonel Byrd did not visit Accokeek furnace. He visited Colonel Spotswood's air furnace at Massaponux, which he fully describes. It was a very ambitious and creditable enterprise, and appears to have been successfully managed. Colonel Spotswood used it "to melt his sow iron, in order to cast it into sundry utensils, such as backs for chimneys, andirons, fenders, plates for hearths, pots, mortars, rollers for gardeners, skillets, boxes for cart wheels, and many other things. And, being cast from the sow iron, are much better than those which come from England, which are cast immediately from the ore for the most part." "Here are two of these air furnaces in one room, that so in case one want repair the other may work, they being exactly of the same structure." Colonel Spotswood informed Colonel Byrd that Robert Cary, of England, was a silent partner of his in all his iron enterprises. In John Esten Cooke's *History of the Virginia People* it

is stated that in 1760 about 600 tons of iron were smelted at "Spotswood's furnaces," most of which was sent to England.

The connection of the Washington family with the iron industry of Virginia and Maryland justifies further reference to the Accokeek furnace. As has been stated in the chapter relating to Maryland, the furnace was ready for work in February, 1726. Custis, in his *Recollections*, relates that Augustine Washington, after the burning of his house in Westmoreland, removed with his family to a situation near Fredericksburg, on the Rappahannock, where he became connected with the Principio Company. Colonel Byrd has partly explained the nature of this connection, and in the Maryland chapter it is still further explained. Mr. Whiteley states that Accokeek became a valuable property. In 1750 this furnace sent to England 410 tons of pig iron, which was about one-sixth of the quantity exported from Maryland and Virginia in that year. Augustine Washington, at his death in 1743, left the estate afterwards known as Mount Vernon, and his one-twelfth interest in all the possessions of the Principio Company, to his son Lawrence, an elder half-brother of George Washington. Lawrence died in 1752.

We have examined the will of Lawrence Washington, of Fairfax county, Virginia, as it is recorded in Albert Welles's *History of the Washington Family*. It is dated June 20, 1752. We make the following literal extract: "I give and bequeath to my daughter Sarah, . . after my just debts are discharged, all my real and personal estate in Virginia and the Province of Maryland, not otherwise disposed of. But in case it should please God my said daughter should die without issue, it is then my will and desire that my estate, both real and personal, be disposed of in the following manner. First. I give and bequeath unto my loving brother Augustine Washington and his heirs forever all my stock, interest, and estate in the Principio, Accokeek, Kingsbury, Laconshire, & No. East iron works, in Virginia and Maryland, reserving one-third of the profits of the said works to be paid my wife as hereafter mentioned." George Washington was one of the executors of this will. Sarah did not long survive her father, and upon her death Augustine Washington succeeded to the ownership of his iron interests, and George Washington succeeded to the

ownership of Mount Vernon. Mr. Whiteley tells us that it was at the solicitation of Augustine Washington, "in behalf of himself and other adventurers in iron works," that in 1757 the Virginia Council remitted the port duties and fees on pig and bar iron imported into that province from Maryland. He also states that Accokeek furnace was abandoned soon after Lawrence Washington's death, owing to the failure of a supply of ore within a reasonable distance. In 1753 the slaves, horses, cattle, and wagons were sold, and affairs were gradually closed up until nothing but the real estate was left, of which Augustine Washington doubtless afterwards became sole owner.

Mr. Brock writes us that, in *Hening's Statutes*, volume IX, there is "an act for the encouragement of iron works," passed in May, 1777, which recites that, "Whereas, the discovery and manufacturing of iron ore requisite for the fabricating the various implements of husbandry, small arms, intrenching tools, anchors, and other things necessary for the army and navy, is at this time essential to the welfare and existence of this State, as the usual supplies of pig and bar iron from foreign States is rendered difficult and uncertain, and James Hunter, near Fredericksburg, hath erected and is now carrying on, at considerable expense and labour, many extensive factories, slitting, plating, and wire mills, and is greatly retarded through the want of pig and bar iron; and whereas, there is a certain tract of land in the county of Stafford, called or known by the name of Accokeek furnace tract, on which a furnace for the making of pig iron was formerly erected and carried on, which has been since discontinued," etc., etc. The act goes on to authorize James Hunter to enter upon two hundred acres of the Accokeek tract, including the old furnace, if its owners or agents should fail in one month to begin and within six months to erect thereon a furnace equal to or larger than the former one, and prosecute the same for the making of pig iron and other castings.

Mr. Chiswell told Colonel Byrd that "we had as yet no forge erected in Virginia, tho' we had four furnaces. But there was a very good one set up at the head of the bay in Maryland, that made exceeding good work." The forge referred to was doubtless the one at Principio, the North East

forge not having been built until about 1735. Colonel Spotswood told Colonel Byrd that "he was not only the first in this country, but the first in North America, who had erected a regular furnace; that they ran altogether upon bloomerys in New England and Pennsylvania till his example had made them attempt greater works." The correctness of this statement can-not be maintained, nor can that of Colonel Byrd, made doubtless on the authority of Colonel Spotswood, that the furnace near Germanna was the first furnace in the country that was "built of rough stone."

In the valley of Virginia many furnaces and forges were built prior to the Revolution, and others were built before the close of the century. Zane's furnace and forge, on Cedar creek, in Frederick county, were "built before any iron works in this region." Pine forge, in Shenandoah county, three and a half miles north of New Market, was built at an early day. Isabella furnace, on Hawksbill creek, near Luray, in Page county, was built about 1760. About 1775 a furnace was built on Mossy creek, Augusta county, by Henry Miller and Mark Bird, of Berks county, Pennsylvania. Bird soon sold his interest to Miller. A forge was soon added to this furnace.

Union forge, near Waynesborough, in Augusta county, was built about 1800. In Rockbridge county were two forges, built about 1800—Gibraltar forge, on North river, nine miles north of Lexington, and Buffalo forge, on Buffalo creek, the same distance south of Lexington. Moore's furnace, on Steele's creek, in this county, and a furnace on Smith's creek, in Rockingham county, were built before 1800.

A furnace was built in Loudon county before 1800, concerning which Bishop states that Mr. Clapham, its owner, "cut a canal through the end of Cotocktin mountain, 500 feet through solid rock and 60 feet beneath the surface, to obtain water for his furnace and mill."

Iron works were erected in Craig, Grayson, Wythe, Washington, Carroll, and other southwestern counties before the close of the last century. A forge on Chestnut creek, in Carroll county, was built about 1790, and another on Little Reed Island creek was built about the same time. Poplar Camp furnace, on Poplar Camp creek, in Wythe county, appears to have been built in 1778, as a stone bearing that date and

identified with the furnace is still preserved. Some of the old charcoal furnaces that are still in existence in Southwestern Virginia retain all their primitive characteristics. They are blown by water-power with wooden "tubs," are placed against a bank of the same level as the tunnel-head, have a cold blast, and are operated by "the rule of thumb." The stacks are built of stone. But even in Southwestern Virginia, which has many of the primitive furnaces referred to, modern methods are now obtaining recognition.

Bishop says that an excellent "air furnace" was built at Westham, six miles above Richmond, on the north side of the James river, during the Revolution; there was also a cannon foundry here at the same period. The "air furnace" is said to have used bituminous coal, from the mines of Chesterfield county, in the manufacture of shot and shells for the Continental army. Benedict Arnold destroyed the works at Westham in 1781. A rolling and slitting mill was afterwards built at this place.

At Lynchburg and in its vicinity, in the James river valley, several furnaces and forges were built in the last century, some of which are referred to in the following extract from Jefferson's *Notes on the State of Virginia*, written in 1781 and 1782, but not printed until 1788.

The mines of iron worked at present are Callaway's, Ross's, and Ballendine's on the south side of James river; Old's on the north side, in Albemarle; Millar's in Augusta, and Zane's in Frederick. These two last are in the valley between the Blue ridge and North mountain. Callaway's, Ross's, Millar's, and Zane's make about 150 tons of bar iron each in the year. Ross's makes also about 1,600 tons of pig iron annually; Ballendine's, 1,000; Callaway's, Millar's, and Zane's, about 600 each. Besides these, a forge of Mr. Hunter's, at Fredericksburg, makes about 300 tons a year of bar iron, from pigs imported from Maryland; and Taylor's forge, on Neapsco of Patowmac, works in the same way, but to what extent I am not informed. The indications of iron in other places are numerous, and dispersed through all the middle country. The toughness of the cast iron of Ross's and Zane's furnaces is very remarkable. Pots and other utensils cast thinner than usual, of this iron, may be safely thrown into or out of the wagons in which they are transported. Salt-pans made of the same, and no longer wanted for that purpose, cannot be broken up, in order to be melted again, unless previously drilled in many parts.

In the western country we are told of iron mines between the Muskingum and Ohio; of others on Kentucky, between the Cumberland and Barren rivers, between Cumberland and Tanissee, on Reedy creek, near the Long island, and on Chestnut creek, a branch of the Great Kanhaway near

where it crosses the Carolina line. What are called the iron-banks, on the Mississippi, are believed, by a good judge, to have no iron in them. In general, from what is hitherto known of that country, it seems to want iron.

This account by Jefferson seems to establish the fact that the iron industry of Virginia was not very extensive about the close of the Revolution. Ross's works were on Beaver creek, seven miles southeast of Lynchburg, and Thomas Callaway's were near Rocky Mount, or Franklin court-house. Lesley mentions Saunders's furnace at the latter place as having been abandoned about 1800. Henry Miller's works were near the northern boundary of Augusta county, "at the foot of North mountain." In 1777 Old's furnace was referred to in the Virginia legislature as an "old furnace" that was "yet standing, tho' somewhat out of repair," but it was proposed to put it in blast, to aid by its product in accomplishing the independence of the colonies. This proposition took the form of a resolution appropriating a loan of £2,000 to one of the proprietors. The furnace was then said to have been owned by Messrs. Old, Wilkinson & Trent, and Wilkinson was the partner to be benefited by the loan from the Virginia treasury. The furnace appears to have been promptly put in blast, as Jefferson says that the mines belonging to this furnace were "worked" when his *Notes* were written. The furnace was located about twelve miles from Charlottesville.

About 1790 the iron industry of Virginia took a fresh start, as did many other manufactures of the State. No State in the Union gave more attention to domestic manufactures after the close of the Revolution than Virginia. This activity continued for many years, but it was partly checked in subsequent years by the greater attention given by the people of Virginia to agricultural pursuits. Richmond, Lynchburg, Staunton, Winchester, and some other places became noted for the extent and variety of their manufactures. Household manufactures were everywhere cultivated. The manufacture of nails was one of these household industries. Thomas Jefferson required about a dozen of the younger slaves owned by him to make nails, and it is said that "they made about a ton of nails a month at a considerable profit." The Government armory at Harper's Ferry was established in 1798.

Lesley enumerates no less than eighty-eight charcoal fur-

naces and fifty-nine forges and bloomaries as having been built in Virginia prior to 1856; also twelve rolling mills. Several of these enterprises were within the limits of the present State of West Virginia. The furnaces were located in thirty-one counties and the forges in twenty-five counties.

The first rolling mill of any kind west of the Allegheny mountains and outside of Pennsylvania of which we can obtain exact information was located in West Virginia, and is described in Cramer's *Pittsburgh Almanac* for 1813, issued in 1812, as follows: "Jackson & Updegraff, on Cheat river, have in operation a furnace, forge, rolling and slitting mill, and nail factory—nails handsome, iron tough." Like all the rolling and slitting mills of that day, the Cheat river mill did not puddle iron nor roll bar iron, but rolled only sheet iron and nail plates from blooms made in forges. Hon. James Veech informed us in his lifetime that its location was on the road from Uniontown to Morgantown, about three miles south of the Pennsylvania State line, and eight miles north of Morgantown. It was in Monongalia county.

In the old days before the civil war Wheeling was the centre of the rolling-mill industry of Virginia, having seven of the twelve rolling mills in the State. Of the remaining five mills, four were in Richmond and one was on Reed creek, in Wythe county, twelve miles east of Wytheville. Since the war two rolling mills have been established at Lynchburg, and new mills have been built at Wheeling. The first rolling mill at Wheeling was built in 1832 by Dr. Peter Shoenberger and David Agnew, both Pennsylvania ironmasters. This mill was called the Wheeling iron works. The firm was styled Shoenberger & Agnew. The most prominent nail-manufacturing district in the United States at the present time is the Wheeling district, which includes the nail factories in West Virginia and in that part of Ohio which lies near Wheeling.

A large number of the furnaces and forges of Virginia were abandoned before 1850. In 1856 there were thirty-nine charcoal furnaces and forty-three forges enumerated by Lesley as being then in operation or prepared to make iron. Since 1856 many of the charcoal furnaces and most of the forges that were then in existence have been abandoned. Insufficient transportation facilities, coupled with the failure

of ore in certain localities, have had much to do with the abandonment of many charcoal furnaces in Virginia, while the disappearance of the forges is due to the competition of rolling mills. Of late years, however, the extension of railroads and the discovery of new and valuable ore deposits have given a fresh impetus to the manufacture of pig iron in Virginia and West Virginia, much of which is made with coke, West Virginia especially supplying an excellent quality of this fuel. The future of the iron industry of these two States is to-day very promising. The young State took higher rank in both 1870 and 1880 among iron-producing States than the old State. It ranked tenth in 1870 and seventh in 1880; whereas Virginia ranked thirteenth in 1870 and sixteenth in 1880. Since 1880, however, the old State has made remarkable progress in the erection of large blast furnaces to use coke as fuel. Some of the best furnaces in the country are now to be found in Virginia. Its total production of pig iron in the calendar year 1880 was only 26,726 tons, but in 1883 it was 136,524 tons.

CHAPTER XX.

THE MANUFACTURE OF IRON IN NORTH CAROLINA.

SCRIVENOR says that in 1728–'29 there were imported into England from "Carolina" one ton and one cwt. of pig iron, and that in 1734 there were imported two qrs. and twelve lbs. of bar iron. Shipments of pig iron and bar iron from "Carolina" were made in subsequent years prior to the Revolution. We regret that we can not locate the early iron enterprises in this State. Some future antiquarian may be able to do this. They were probably situated near the coast in the neighborhood of bog-ore deposits. It is a curious fact that hoes made in Virginia and "Carolina" were sold in New York long before the Revolution.

Bishop says that several iron works were in operation in North Carolina before the Revolution, some of which were put out of blast by that event. They were situated on branches of the Cape Fear, Yadkin, and Dan rivers. When the shadow of the approaching conflict with the mother country reached North Carolina, her patriotic citizens, first in convention at New Berne and afterwards in the provincial legislature, encouraged by the offer of liberal premiums the manufacture of crude and finished iron and steel, as well as other manufactured products. "John Wilcox was the proprietor of a furnace and iron works on Deep run in the beginning of the war. There were also iron works in Guilford county, probably on the same stream. In April, 1776, the provincial congress sent commissioners to treat with Mr. Wilcox for the use of his furnace and works for two years, or to purchase and repair those in Guilford, for casting ordnance, shot, etc., and empowered them to draw on the treasury for £5,000 for that purpose." Troublesome forge, in Guilford county, was in operation during the Revolution. Buffalo Creek furnace and forge were also built before the Revolution on Buffalo creek, in Cleveland county, not far from King's mountain, on the southern border of the State.

Prior to 1800 there were in operation in Lincoln county

four forges, two bloomaries, and two furnaces. One of the furnaces, Vesuvius, on Anderson's creek, built in 1780, was in operation down to 1873. Of other iron enterprises established in North Carolina in the last century we gather from Lesley and Bishop, and from Dr. William Sharswood, a local historian, of Danbury, North Carolina, the following information: Union bloomary forge, on Snow creek, in Stokes county, six miles northeast of Danbury, was built in 1780 by Peter Perkins and James Martin. Other iron works were built on Snow creek, in the same county, and conducted with spirit before 1800. Dr. Sharswood mentions a furnace and forge on this creek which were built by Peter Perkins and James Taylor about 1795; they were located about half a mile from the mouth of the creek. Davis's mills now stand on the site of the furnace. He also says that Matthew Moore built a forge on Big creek, where George's mill now stands, before 1800. Kiser's bloomary forge, on the headwaters of Town fork, in the same county, ten miles southwest of Danbury, was built in 1796 by George Hauser and Philip Kiser. Hill's bloomary forge, on Tom's creek, in Surry county, nineteen miles west of Danbury, was built in 1791. In the same county, near the Yadkin, iron works were erected a few years after the Revolution, probably by Moravians from Pennsylvania, who had settled in the county as early as 1753. In Wilkes county a forge was built about the same time. A furnace and forge were erected on Troublesome creek, in Rockingham county, at an early day. In Burke county, at the foot of the Blue ridge, two bloomaries and two forges were erected before the close of the last century.

After 1800 the iron industry of North Carolina was still further developed. This development was, however, mainly confined to the manufacture of iron in bloomaries, the magnetic and hematite ores of North Carolina being well adapted to this primitive mode of treatment. In 1810, according to Tench Coxe, there were six bloomaries, two rolling and slitting mills, and two naileries in Lincoln county; one bloomary in Iredell county; six bloomaries and one trip-hammer in Burke county; and five bloomaries in Surry county—eighteen bloomaries in all. In 1856 Lesley enumerated about forty bloomaries and a few forges, most of which were then

in operation. They were located in Stokes, Surry, Yadkin, Catawba, Lincoln, Gaston, Cleveland, Rutherford, Ashe, Watauga, and Cherokee counties. The *trompe* was in general use. He also described six furnaces: Vesuvius, already referred to; Madison, on Leiper's creek, in Lincoln county, built in 1810; Rehoboth, on the same creek and in the same county, built in 1810; Columbia, seven miles west of High Shoals, in Gaston county, then in ruins; Tom's Creek, near Hill's forge, on Tom's creek, destroyed by a flood in 1850; Buffalo Creek, already referred to, and then in ruins. Vesuvius, Madison, and Rehoboth were blown with wooden "tubs." There was also active at this date a small rolling mill on Crowder's creek, in Gaston county, a mile and a quarter north of King's mountain, owned by Benjamin F. Briggs, of Yorkville, South Carolina, and built in 1853. At the same time another small rolling mill and forge, known as High Shoals iron works, and situated in Gaston county, were in ruins.

There have been other early iron works in North Carolina than those mentioned by Lesley or the other authorities from whom we have quoted. Iron was made in a bloomary near the line of Nash and Wilson counties in the war of 1812, and during the civil war iron was made in a blast furnace in the same locality. About 1840 there was a furnace called Shuford in Catawba county, and at the same period there was a furnace called Beard's on the Catawba river, probably in Catawba county. Iron was also made about the same time on Gunpowder creek, in Caldwell county, probably in a bloomary.

In Mitchell county, in the northwestern part of the State, and within a few miles of the Tennessee line, occurs one of the richest and most extensive deposits of iron ore in the world, known as the Cranberry mines, the deposit taking its name from Cranberry creek, which flows at the foot of the steep mountain spurs in which the ore is found. This ore is a pure magnetite, granular in structure, and practically free from sulphur and phosphorus. This valuable deposit is now being developed by Northern capital. The Cranberry Iron Company is prepared to ship ore to distant furnaces, and it has also built at the mines a small charcoal furnace which was put in blast in the spring of 1884. Cranberry ore has long been worked in bloomaries in the neighborhood.

At least two furnaces were built in North Carolina during the civil war, one in Chatham and one in Lincoln county, and two were built in Chatham county after the war, but of these four furnaces, and Vesuvius, Madison, and Rehoboth, all of which are still standing, as may possibly be one or two other furnaces, not one made a pound of iron from 1877 until 1881. In that year Rehoboth furnace was in operation, and in 1882 it was still active, but in 1883 it was silent. The furnace built in Lincoln county during the war was named Stonewall. Nearly all of the iron works in North Carolina that have been referred to have been built in the western part of the State. Of the long list of bloomaries and forges which North Carolina could once boast less than a dozen are now active, and there is not to-day a rolling mill or steel works in the State.

CHAPTER XXI.

THE MANUFACTURE OF IRON IN SOUTH CAROLINA.

If the iron industry of North Carolina has declined in late years, that of South Carolina has suffered a worse fate; it has been an extinct industry for many years. Yet this State made some iron as early as the Revolutionary period, and subsequently it made iron in considerable quantities. In the northwestern part of South Carolina, including the counties of Union, Spartanburg, and York, are valuable deposits of magnetic ores, and here, according to Dr. Ramsay, the historian of South Carolina, the first iron works in the State were erected by Mr. Buffington in 1773, but they were destroyed by the Tories during the Revolution.

At the beginning of the Revolution South Carolina followed the example of many other colonies by offering liberal premiums to those who would establish iron works, but we do not learn that the manufacture of iron was thereby increased. Mr. Buffington's experience probably deterred others from embarking in the business.

Several furnaces and forges were erected in this State a few years after the peace, the principal of which were the Era and Etna furnaces and forges in York county. The Era was built in 1787 and the Etna in 1788. These enterprises were situated on a creek flowing into the Catawba river, and about two miles west of it. In 1795 the nearest landing to these works was at Camden, seventy miles below. They were on the road leading from Charlotte, in North Carolina, to Yorkville. Iron ore was abundant in the neighborhood, and was easily smelted after having been roasted. "It was obtained, massive, in such quantity above the surface that it was thought there would be no occasion to resort to shafts or levels for half a century." William Hill was one of the principal owners of the works. He is said to have devised "a new blowing apparatus," by the aid of which he contrived to blow "all the fires, both of the forges and furnaces, so as to render unnecessary the use of wheels, cylinders, or any other

kind of bellows." This apparatus was undoubtedly the *trompe*, or water-blast, but Mr. Hill did not invent it, nor was he the first in this country to use it. The statement, which Bishop quotes from some unknown authority, is, however, valuable, as it contains one of the very few references to the use of the *trompe* in this country in blowing a blast furnace that have come under our notice. Bishop says that other iron works soon followed those of Mr. Hill, and that "they were erected in different places, including several in the mountain district of Washington, where iron, the only article made for sale to any extent, was manufactured, at the beginning of this century, as cheap and good as the imported."

In 1810 Tench Coxe enumerates two bloomaries in Spartanburg county, four in Pendleton county, two in Greenville county, and one in York county—nine in all. He also mentions one small nailery and one small steel furnace in the State. He makes no reference to blast furnaces, but his statistics were evidently not complete.

Scrivenor mentions the following iron enterprises in South Carolina as existing apparently about 1815: "On Allison's creek, in York district, there are a forge, a furnace, a rolling mill for making sheet iron, and a nail manufactory. On Middle Tiger river are iron works on a small scale; also on the Enoree river and Rudy river, on the north fork of Saluda river, on George's creek, and on Twenty-six-mile creek. In 1802 an air-furnace was erected on a neck of land between Cooper and Ashley rivers, where good castings are made." York district is the same as York county, the subdivisions of South Carolina having been known as districts down to 1868.

In 1856 South Carolina had eight furnaces—one in York, one in Union, and six in Spartanburg county. They are described by Lesley. Four of these furnaces were then in operation, producing in the year named 1,506 tons of charcoal iron, but three others had been "out of repair for twenty years," and the remaining furnace had been abandoned. In 1856 there were also three small rolling mills in the State—one on Pacolet river, in Spartanburg county; one on Broad river, in Union county; and one on the same river, in York county. At the first two of these mills dry wood was used in the puddling and heating furnaces. In 1856 the three mills

made 1,210 tons of bar iron and nails. In the same year there were also in South Carolina two "bloomaries," one connected with the rolling mill in Union county, and the other connected with the rolling mill in York county. Their joint product was 640 tons of blooms. But South Carolina no longer makes iron. Every iron-producing establishment in the State is to-day silent, and has been silent for many years, and all are in a more or less dilapidated condition. South Carolina furnishes the only instance in the history of the country of a State having wholly abandoned the manufacture of iron.

CHAPTER XXII.

THE EARLY MANUFACTURE OF IRON IN GEORGIA.

Georgia is the last of the original thirteen colonies whose iron history remains to be noticed. Unlike its sister colonies, however, Georgia has no colonial iron history. It was the last of the thirteen to be settled, and it was not until within a few years of the commencement of the Revolutionary struggle that the few settlements on the coast began to experience even moderate prosperity. After the close of the Revolution the settlement of the interior was for many years retarded by difficulties with the Indians, and it was not until 1838 that the Cherokees were induced to surrender their claims to a portion of the territory of the State. It will be seen that, under the circumstances which have been mentioned, the manufacture of iron in Georgia was destined to be the result almost entirely of modern enterprise.

In 1810 there was a bloomary in Warren county, a forge in Elbert county, and a nailery in Chatham county. Two of these enterprises were near the Atlantic coast, and were doubtless among the first of their kind in the State, dating probably from about 1790. The coast sections of Georgia did not possess ample resources for the manufacture of iron. No iron industry exists there to-day. Sequee bloomary forge, three miles south of Clarkesville, in Habersham county, was built about 1830, and abandoned about 1835. Hodge's forge, in the same county, was probably built at an earlier date. Lesley says of it: "Situation unknown; history unknown; abandoned very long ago."

Bloomary forges in Cass county, now Bartow county, were built as follows: Etowah, No. 1, in 1838; Etowah, No. 2, in 1841; Allatoona, about 1846. Ivy Log bloomary, in Union county, was built about 1839. Aliculsie bloomary, in Murray county, was built about 1843. A bloomary was built on Armuchy creek, in Walker county, about 1848. Lookout bloomary, in Dade county, was built at an earlier day. All of these enterprises were abandoned before 1856, in which year, how-

ever, several other bloomaries of more recent origin were in operation. In 1880 only two bloomaries in the State were reported to be in use. One forge, at Allatoona, made blooms from scrap iron in that year.

The first furnace in Georgia of which we have any account was Sequee furnace, built prior to 1832, near Clarkesville, in Habersham county, and abandoned in 1837. Etowah furnace, on Stamp creek, in Cass county, now Bartow county, was built in 1837, abandoned in 1844, and torn down in 1850. A new furnace, built by its side in 1844, is now in ruins. Allatoona furnace, in Cass county, built in 1844; Union furnace, in the same county, built in 1852; Lewis furnace, in the same county, built about 1847; and Cartersville furnace, in the same county, built in 1852, have been abandoned. Clear Creek furnace, in Walker county, built about 1852, and rebuilt in 1857, has also been abandoned. All of these were charcoal furnaces. Of the furnaces existing in Georgia in 1880 Bartow county contained five charcoal furnaces and two coke furnaces—seven in all. Of these the two Bear Mountain charcoal furnaces, built in 1842, were the oldest. Four other furnaces in the State were situated in Polk, Floyd, and Dade counties —two in Polk and one in Floyd using charcoal, and one in Dade using coke. Of the eleven furnaces in the State in 1880, some of which were not then active, several have since been torn down or abandoned. Rising Fawn furnace, in Dade county, is 63 feet high by 16 feet wide at the boshes, and was the first furnace in the United States to use the Whitwell hot-blast stove, blowing in for the first time on June 18, 1875.

Georgia had two rolling mills in 1859—Etowah, in Cass county, built about 1849, and Gate City, at Atlanta, built in 1858. It is a curious fact that the State had just two rolling mills twenty-one years later, in 1880,—Atlanta, built in 1865, and Rome, built in 1869. The latter had been idle for several years prior to 1880, and has since been dismantled. The Atlanta rolling mill was burned on September 21, 1881. There is now not one rolling mill, large or small, in the State. Lesley, in 1859, thus describes the Etowah rolling mill and its blast furnace and other connections, situated on the Etowah river: "This property has been building up and developing

for twelve years. On it there has been expended $250,000. It contains a rolling mill, nail and spike factory, and all necessary apparatus; a blast furnace and foundry, with full equipment; a wheat mill (150 to 250 bushels per day), warehouse, cooper-house, hotel, and operative houses, two corn grist mills, two saw mills, and a coal mine; all using not one-tenth of the water-power on the premises. River 600 feet wide. Iron ore and wood are abundant. It is on the metamorphic rocks of the gold and copper belt, both minerals being found on it," etc.

Notwithstanding the decadence of its bloomaries, and the signal failure it has made in building up a rolling-mill industry, Georgia possesses to-day a firmly-established although small blast-furnace industry, which has been almost wholly rehabilitated during the past decade, and which promises to grow in the immediate future. It must be said, however, that the iron industry of Georgia is not now so prominent as in former years.

CHAPTER XXIII.

THE EARLY MANUFACTURE OF IRON IN KENTUCKY.

THE first iron enterprise in Kentucky whose history has been preserved was Bourbon furnace, often called Slate furnace, which was built in 1791 on Slate creek, a branch of Licking river, in Bath county, then Bourbon, and about two miles southeast of Owingsville. This is also the only furnace in Kentucky which has a history that can be traced back to the last century. It will be remembered that Jefferson, in the extract from his *Notes on the State of Virginia*, already quoted, says that there were iron mines "on Kentucky, between the Cumberland and Barren rivers," and also "between Cumberland and Tanissee." This was written before the close of the Revolution. Bourbon furnace was not within the limits of any of these boundaries, but was located not far from the Ohio river. Nor is it probable that there were any iron enterprises in the Kentucky portion of the regions mentioned by Jefferson prior to the building of Bourbon furnace. This furnace was the first *furnace* outside of the present limits of the original thirteen colonies of which we can obtain any information.

We have received from V. B. Young, Esq., of Owingsville, a very full historical account of Bourbon furnace, which we condense as follows:

In October, 1782, Jacob Myers came from Baltimore, Maryland, to the region now embraced in Bath county, Kentucky, but then in Bourbon county, and soon afterwards patented 5,434 acres of land on Slate creek. In March, 1791, he commenced the erection of a furnace on this land, and on the 24th of May following he sold to John Cockey Owings, of Baltimore, Christopher Greenup, of Mercer county, Kentucky, Walter Beall, of Nelson county, Kentucky, and Willis Green, of Lincoln county, Kentucky, seven-eighths of his interest in the furnace and in the land, the consideration being £1,426 8s. 6d. On the same day all the persons mentioned formed themselves into a company and subscribed to an agreement which stipulated that "the furnace now building on Slate creek shall hereafter be styled, called, and known by the name of the Bourbon furnace, and the firm of the company shall be John Cockey Owings and Company, owners and proprietors of the Bourbon furnace." During the erection of the furnace, and afterwards while the hands employed by the company were digging ore, the workmen had to be guarded by men with guns against the In-

dians; hence it became necessary to build a strong block-house on the principal ore bank for the better security of the laborers. The first blast made by the furnace was in 1792.

On March 6, 1795, George Thompson, Colonel George Nicholas, John Breckinridge, and John Hollingsworth became members of the company, adding to its capital lands and other property equal in value to the original investment. On June 29, 1798, Christopher Greenup sold his interest to George Nicholas and Walter Beall. In July, 1799, George Nicholas died. On January 15, 1800, Walter Beall sold his interest to Colonel Thomas Dye Owings, a son of John Cockey Owings, who had inherited his father's interest. In 1806 Colonel Owings became the sole owner of Bourbon furnace. He operated it successfully until 1822, when he became involved in debt and was compelled to make an assignment. The furnace was then operated by trustees for several years, when it was sold for the benefit of the creditors, passing into the hands of Robert Wickliffe, of Lexington, Kentucky, who leased it to Major John C. Mason and Samuel Herndon, who operated it until August, 1839, when its last blast came to an end. The stack is still standing.

The owners of Bourbon furnace built Slate forge, on Slate creek, three miles above the furnace, in 1798, to convert its pig iron into bar iron. This forge was in operation until 1818. Maria forge, three miles above the mouth of Slate creek, was built for the same purpose in 1810 by Joseph and Carlisle Harrison. It was in operation until 1840.

Bourbon furnace used the Clinton ore from two banks two miles south of the furnace—one called the Howard hill bank and the other called the Block-house bank. The water-power furnished by Slate creek was often insufficient to keep the furnace working regularly. The production of the furnace was about three tons per day. The iron made at the furnace had a poor reputation for strength, but it was very hard, which was due to the large amount of phosphorus it contained.

Bourbon furnace supplied the early settlers of Kentucky with all the castings they needed, such as heating stoves, cooking utensils, flat-irons, etc. After Slate forge was built the blacksmiths of the State were supplied by it with bar iron. The castings and bar iron were hauled in wagons to all parts of the State, and distributed through the principal stores in the towns. There are many heating stoves and cooking utensils still in use in Kentucky that were made at this furnace. Products of the furnace and the forge were also hauled to Licking river, a distance of seven miles, and put into flat-boats and floated to Cincinnati and Louisville on the Ohio.

In 1810 Colonel Owings had a contract with the United States Government to furnish cannon balls, grape shot, etc., to the navy. He also furnished General Jackson with cannon balls, grape shot, chain shot, etc., to use against the British, and they were so used at the battle of New Orleans on the 8th of January, 1815. I have in my possession the original receipt of General Jackson's sergeant-major for the cannon balls, etc., and also the receipts of several naval officers.

The owners of Bourbon furnace carried on a large general store. They brought their goods from Philadelphia. The Kentucky merchant in those early days traveled all the way to Philadelphia on horseback, carrying in saddle-bags the silver to pay for his goods. They brought their goods in

wagons to Pittsburgh, thence down the Ohio on flat-boats to the mouth of the Limestone, now Maysville, in Mason county, Kentucky, and thence hauled them to the furnace, a distance of forty-five miles. The company also built and carried on a grist mill, which had a widely extended custom.

The founders and early owners of Bourbon furnace were all remarkable men, and their names are among the most eminent in the history of Kentucky. Jacob Myers, the pioneer, was a German, and a man of very fine sense. Christopher Greenup was a Virginian by birth, a soldier in the Revolution, a member of Congress from Kentucky in 1792, and Governor of Kentucky from 1804 to 1808. Greenup county was named after him. He died in 1818 in his 69th year. George Nicholas was a Virginian by birth, and a great lawyer and a great statesman. He was a soldier in the Revolution, was a member of the convention to frame a Constitution for Kentucky, was the author of that instrument, and was the first Attorney-General of the State. John Breckinridge was a Virginian by birth, and was the author of the Kentucky Resolutions of 1798. He was a United States Senator from Kentucky in 1801, and was appointed Attorney-General of the United States in 1805. He was the grandfather of Vice-President John C. Breckinridge. Walter Beall and Willis Green were surveyors from Virginia, and the latter held various local offices in Kentucky. John Cockey Owings was a large landholder in Maryland.

The original of the following memorandum was handed to the editor of the Portsmouth (Ohio) *Tribune* in 1880 by Mr. L. C. Robinson. It refers to Bourbon furnace.

KENTUCKY, *ss.:* Memorandum of an Agreement made and Concluded upon this day between John Cockey Owings & Co., in Iron Works at the *Bourbon* Furnace of the one part, and Robert Williams (potter) of the other part. Witnesseth that the aforesaid Company doth this day agree to give the said Williams five pounds p. month for three months' work and to find him provisions during the time he shall work until the three months are expired, and said Company doth further agree, in case the furnace is not ready to blow before or at the expiration of the three months, if the water will admit, or as soon as the water will admit after that time, to give him p. month as much as he can make in a month at the potting Business for such time as said Furnace may not be Ready to put in Blast—as witness our hands this second day of June, 1793.

JN. COCKEY OWINGS,
WALTER BEALL,
CHRIST GREENUP.

Test: JNO. MOCKBEE.

For a number of years after 1800 the iron industry of Kentucky made steady progress. Tench Coxe in 1810 mentions only four furnaces and three forges. One furnace was in Estill, one in Wayne, and two were in Montgomery county. One of the forges was in Estill, one in Wayne, and one in Montgomery county. His enumeration is, however, incomplete, no mention, for instance, being made of the iron enter-

prises in Bath county. In the same year, or soon afterwards, there were four nail factories at Lexington, making seventy tons of nails annually.

About 1815 Richard Deering, a farmer of Greenup county, smelted in a cupola the first iron ore used in the Hanging Rock district of Kentucky. His experiment with the cupola proving to be successful, he took into partnership David and John Trimble, and these three persons erected as early as 1817 the first blast furnace in the district. It was called Argillite, and was located in Greenup county, about six miles southwest of Greenupsburg, upon the left bank of the Little Sandy river. The stack, which was 25 feet high and 6 feet wide at the boshes, was cut in a cliff of black slate—hence the name, Argillite. Lesley says: "It was not a structure, but an excavation in the solid slate rock of the cliff, the archway below being excavated to meet it." This furnace was operated until 1837, when it was abandoned, its product was always small.

The next furnace in this district appears to have been Pactolus, built by Ward & McMurtry in 1824, on the Little Sandy river, in Carter county, above Argillite furnace. It was abandoned about 1837. A forge was connected with this furnace. The next iron enterprise in the district is said to have been Steam furnace, in Greenup county, situated about three miles from the Ohio river and five miles from Greenupsburg. It was built in 1824 by Leven Shreeves & Brother, and was operated with steam. It was abandoned after 1860. Enterprise furnace, on Tygart's creek, in Greenup county, was built in 1826, but Richard Deering is said to have erected a forge of the same name, on the same creek, in 1824. Bellefonte furnace, on Hood's creek, two and a half miles southwest of Ashland, in Boyd county, was built in 1826 by A. Paull, George Poague, and others, and was the first furnace in this county. It was in operation in 1883.

Between 1817 and 1834 at least thirteen furnaces were built in Greenup, Carter, and Boyd counties. One of the earliest of these was Camp Branch, or Farewell, situated on Little Sandy river, fourteen miles from Greenupsburg, near the Carter county line, built by David and John Trimble. Subsequent to 1834 about fifteen other charcoal furnaces were

built in these three counties and in Lawrence county. Many of the charcoal furnaces of this district have been abandoned. A few excellent bituminous coal and coke furnaces have, however, been erected in late years. Notwithstanding these additions to its furnace capacity, this district is not now so prominent in the manufacture of iron as it has been.

About 1830 there were a dozen forges in Greenup, Estill, Edmonson, and Crittenden counties, all of which, with one exception, were abandoned before 1850. Two forges were built below Eddyville, in Lyon county, about 1840. All of the forges mentioned refined pig iron into blooms, many of which found a market at Pittsburgh, Cincinnati, and Kentucky rolling mills. There is now only one forge in the State—Red River, in Estill county, and it is not active. If any bloomaries ever existed in Kentucky they were abandoned early in this century.

In addition to the iron enterprises in the Hanging Rock region of Kentucky, furnaces were built before 1860 in several of the middle and western counties of the State—in Bath, Russell, Bullitt, Nelson, Muhlenburg, Lyon, Crittenden, Trigg, Calloway, and Livingston counties. Two of these furnaces, Caney and Clear Creek, were in Bath county. In this period eight rolling mills were also built in Kentucky. The period from about 1825 to 1860 witnessed great activity in the development of the iron industry of Kentucky. Since the close of the civil war this activity has not been maintained. It can not be said that the State has devoted that attention to the manufacture of iron which its position and resources most certainly invite. It was seventh in the list of iron-producing States in 1870, and eleventh in 1880. Of twenty-two furnaces in the State in 1880, eighteen used charcoal, the others using bituminous coal. In the same year there were eight rolling mills—two at Covington, two at Newport, two at Louisville, one at Ashland, and one in Lyon county; there were also two steel works. The first rolling mill in Kentucky appears to have been built at Covington in 1829, a portion of its machinery having been obtained from the dismantled Union rolling mill at Pittsburgh. Ashland, in Boyd county, has recently become prominent as an iron centre.

CHAPTER XXIV.

THE EARLY MANUFACTURE OF IRON IN TENNESSEE.

THE first settlers of Tennessee erected iron works within its limits soon after the close of the Revolution. Bishop says that a bloomary was built in 1790 at Emeryville, in Washington county. At Elizabethton, on Doe river, in Carter county, a bloomary was built about 1795. Wagner's bloomary, on Roane creek, in Johnson county, is said to have been built in this year. A bloomary was also erected on Camp creek, in Greene county, in 1797. Two bloomaries in Jefferson county —the Mossy Creek forge, ten miles north of Dandridge, and Dumpling forge, five miles west of Dandridge—were built in the same year. About the same time, if not earlier, David Ross, the proprietor of iron works in Campbell county, Virginia, erected a large furnace and forge at the junction of the two forks of the Holston river, in Sullivan county, near the Virginia line, on "the great road from Knoxville to Philadelphia." Bishop states an interesting fact in the following words: "Boats of twenty-five tons burden could ascend to Ross's iron works, nearly 1,000 miles above the mouth of the Tennessee, and about 280 above Nashville. At Long Island, a short distance above, on the Holston, where the first permanent settlement in Tennessee was made in 1775, boats were built to transport iron and castings made in considerable quantities at these works, with other produce, to the lower settlements and New Orleans." A bloomary was built about 1795 below the mouth of the Watauga, and another at the same time about twenty-five miles above the mouth of French Broad river and thirty miles above Knoxville.

All of the above-mentioned enterprises were in East Tennessee. In West Tennessee iron was also made in the last decade of the last century. Nashville was founded in 1780, and a few years later iron ore was discovered about thirty miles west of the future city. Between 1790 and 1795 Cumberland furnace was erected on Iron fork of Barton's creek, in Dickson county, seven miles northwest of Charlotte. This furnace was

rebuilt in 1825, and was in operation in 1883. Dickson county and its near neighbors, Stewart and Montgomery counties, afterwards became very prominent in the manufacture of charcoal pig iron. Other counties in the same section of the State have also, but in a less conspicuous degree, made iron in charcoal furnaces. The first furnace in Montgomery county was probably Yellow Creek, situated fourteen miles southwest of Clarksville, and built in 1802.

The iron industry of Tennessee made steady progress after the opening of the present century. Both furnaces and bloomaries multiplied rapidly. In 1856 Lesley enumerated over seventy-five forges and bloomaries, seventy-one furnaces, and four rolling mills in Tennessee, each of which had been in operation at some period after 1790. Of the furnaces, twenty-nine were in East Tennessee, and forty-two in Middle and West Tennessee. Of the latter, fourteen were in Stewart county, twelve in Montgomery, seven in Dickson, two in Hickman, two in Perry, two in Decatur, two in Wayne, and one in Hardin county. There were at one time forty-one furnaces on the Cumberland river in Tennessee and Kentucky. The furnaces in East Tennessee were mainly in Sullivan and Carter counties, Sullivan having five and Carter seven; but Johnson, Washington, Greene, Cocke, Sevier, Monroe, Hamilton, Claiborne, Campbell, Grainger, and Union counties each had one or two furnaces, while Roane county had three. There was a very early furnace in Polk county, which is not noted by Lesley but is mentioned by Bishop. The forges and bloomaries were mainly located in East Tennessee. Johnson county contained fifteen, Carter ten, Sullivan six, Washington three, Greene ten, Campbell seven, Blount four, Roane seven, Rhea three, and a few other counties one and two each. Nearly all of these were bloomaries. In West Tennessee there were less than a dozen refinery forges, and one or two bloomaries. The forges of West Tennessee, like those of Kentucky, were largely employed from about 1825 to 1860 in the manufacture of blooms for rolling mills, many of which were sold to mills in the Ohio valley. Most of the furnaces, forges, and bloomaries enumerated by Lesley have long been abandoned. There still remain in Tennessee twelve charcoal furnaces and about twenty forges and bloomaries. There were also in Tennessee

in 1883 eight bituminous furnaces—all of recent origin, four rolling mills, and two steel works. Cumberland rolling mill, on the left bank of the Cumberland river, in Stewart county, was built in 1829, and was probably the first rolling mill in the State. It was the only rolling mill in Tennessee as late as 1856.

Since the close of the civil war Chattanooga has become the most prominent iron centre in Tennessee, having several iron enterprises of its own and others in the vicinity. Prior to the war Bluff furnace had been built in 1854 to use charcoal, and at the beginning of the war, in 1861, S. B. Lowe commenced the erection of the Vulcan rolling mill, to roll bar iron. This mill was not finished in 1863, when it was burned by the Union forces. Mr. Lowe rebuilt the mill in 1866. It is now owned and operated by the South Tredegar Iron Company. In 1864 a rolling mill to re-roll iron rails was erected by the United States Government, under the supervision of John Fritz, then superintendent of the Cambria iron works. It is now owned and operated by the Roane Iron Company. The first open-hearth steel made in any Southern State was made by the Siemens-Martin process at Chattanooga, by this company, on the 6th day of June, 1878. Lookout rolling mill was built by the Tennessee Iron and Steel Company in 1876, and was started in October of that year. Lewis Scofield was at the time the president of the company. The prominence of Chattanooga as an iron centre is partly due to the excellent bituminous coal which is found in the neighborhood, and partly to its superior transportation facilities. Next to Chattanooga the most prominent iron centre in Tennessee is at Knoxville, which has a varied and prosperous iron industry.

Tennessee is destined to become much more prominent in the manufacture of iron than it has ever been. It will owe this prominence largely to the abundance of good bituminous coal which it possesses, but largely also to the improvements in the manufacture of charcoal pig iron which have already been adopted in many instances in this State, and which are certain to be generally adopted at an early day. Of the good quality of Tennessee ores nothing needs to be said.

CHAPTER XXV.

PRIMITIVE CHARACTER OF THE IRON WORKS OF NORTH CAROLINA AND TENNESSEE.

The establishment at an early day of so many charcoal furnaces and bloomaries in Western North Carolina and East Tennessee—sections of our country remote from the sea-coast and from principal rivers—is an interesting fact in the iron history of the country. The people who built these furnaces and bloomaries were not only courageous and enterprising, but they appear to have been born with an instinct for making iron. Wherever they went they seem to have searched for iron ore, and having found it their small charcoal furnaces and bloomaries soon followed, the furnaces to produce castings and the bloomaries to make bar iron. No States in the Union have shown in their early history more intelligent appreciation of the value of an iron industry than North Carolina and Tennessee, and none have been more prompt to establish it. It is true that their aim has been mainly to supply their own wants, but this is a praiseworthy motive, and people are not to be found fault with if a lack of capital and of means of transportation prevents them from cultivating a commercial spirit.

The enterprise of the early iron-workers of Western North Carolina and East Tennessee assumes a picturesque aspect when viewed in connection with the primitive methods of manufacture which were employed by them, and which have been continued in use until the present day. Their charcoal furnaces were blown through one tuyere with wooden "tubs" adjusted to attachments which were slow in motion, and which did not make the best use of the water-power that was often insufficiently supplied by mountain streams of limited volume. A ton or two of iron a day, usually in the shape of castings, was a good yield. The bloomaries, with scarcely an exception, were furnished with the *trompe*, or water-blast, a small stream with a suitable fall supplying both the blast for the fires and the power which turned the wheel that moved

the hammer. Of cast-iron cylinders, steam-power, two and three tuyeres, and many other valuable improvements in the charcoal-iron industry these people knew but little, and that little was mainly hearsay. They were pioneers and frontiersmen in every sense; from the great world of invention and progress they were shut out by mountains and streams and hundreds of miles of unsubdued forest. Nor would other than primitive methods of manufacturing iron have been adapted to their wants and their isolated condition. It is to their credit that they diligently sought to utilize the resources which they found under their feet, and that they made good use of the only means for the accomplishment of this purpose of which they had any knowledge.

It is a curious fact that the daring men who pushed their way into the wilds of Western North Carolina and East Tennessee in the last century, and who set up their small furnaces and bloomaries when forts yet took the place of hamlets, founded an iron industry which still retains many of the primitive features that at first characterized it. There are furnaces still in operation in these sections which use wooden "tubs," and there are to-day in Tennessee about two dozen bloomaries, and in North Carolina a dozen or more, which are in all respects the counterparts in construction of those which the pioneers established. Nearly every one of these bloomaries is blown with the *trompe*, and in all other respects they are as barren of modern appliances as if the world's iron industry and the world itself had stood still for a hundred years. They are fitfully operated, as the wants of their owners or of the neighboring farmers and blacksmiths require, or as the supply of water for the *trompes* and hammers will permit. "Thundergust forges" is an irreverent term that is frequently applied to them. They furnish their respective neighborhoods with iron for horseshoes, wagon-tires, and harrow-teeth. Mr. J. B. Killebrew, of Nashville, informs us that throughout the counties of Johnson and Carter, in Tennessee, where many of these bloomaries are located, bar iron is still used as currency. He says: "Iron is taken in exchange for shoes, coffee, sugar, calico, salt, and domestic and other articles used by the people of the country. It is considered a legal tender in the settlement of all dues and liabilities. This bar

iron, after being collected by the merchants, is sent out and sold in Knoxville, Bristol, and other points affording a market."

The explanation of the survival in this day and in this country of primitive methods of making iron which have long been abandoned by progressive communities lies in the fact that the environments which hedged about the pioneers of Western North Carolina and East Tennessee have never been broken down, and have been only slightly modified. Few of the mountains and streams and forests of these sections have been tunneled, or bridged, or traversed by modern means of communication. The iron horse has made but slow progress in bringing this part of our country into association with other sections. Cut off by their isolated situation and their poverty from all intimate relations with the outside world, the pioneers we have mentioned are not to be blamed for not adopting modern methods and for clinging to the customs of their fathers. They are rather to be praised for the efforts they have made to help themselves with such simple methods as they could command.

But old things must pass away, even in the iron industry of North Carolina and Tennessee. At Chattanooga, Rockwood, Oakdale, Knoxville, South Pittsburg, and Cowan the transformation in Tennessee has already commenced. North Carolina, with its magnificent iron and other resources, must soon feel the pulse of a new industrial life. Before this century closes the people of whom we have been writing will wonder that the old ways of making iron stayed with them so long.

There are a few ore bloomaries still left in Southwestern Virginia which are similar in all respects to those of Western North Carolina and East Tennessee, and which are used for precisely similar purposes. But the manufacture of iron in bloomaries was never so prominent a branch of the iron industry of Virginia as of the other two States mentioned. Virginia learned at an early day to convert the pig iron of its furnaces into bar iron in refinery forges.

CHAPTER XXVI.

THE MANUFACTURE OF IRON IN ALABAMA.

The earliest furnace in Alabama mentioned by Lesley was built about 1818, a few miles west of Russellville, in Franklin county, and abandoned in 1827. This unsuccessful venture appears to have had a dispiriting effect on other schemes to build furnaces in Alabama, as we do not hear of the erection of any for many years after it was abandoned. A furnace was built at Polksville, in Calhoun county, in 1843; one at Round Mountain, in Cherokee county, in 1852; and Shelby furnace at Shelby, in Shelby county, in 1848. These were all charcoal furnaces, and were the only ones in Alabama enumerated by Lesley in 1856. The total product in that year of the three last-named furnaces was 1,495 tons. Shelby furnace was built by Horace Ware, who many years afterwards added a small foundry and a small mill for rolling cotton-ties and bar iron. The furnace was burned in 1858, but was immediately rebuilt. The mill was commenced in 1859, and on the 11th of April, 1860, the first iron was rolled. It was burned in April, 1865, by General Wilson's command of Union troops, and has not been rebuilt.

Alabama had a bloomary two and a half miles southwest of Montevallo, in Shelby county, in 1825; several bloomaries in Bibb county between 1830 and 1840; one in Talladega county in 1842; two in Calhoun county in 1843; and others in various counties at later periods. In 1856 Lesley mentioned seventeen forges and bloomaries, mostly the latter, as having been built at various periods prior to that year, about one-half of which were then in operation, producing 252 tons of blooms and bar iron. Since 1856 all of the forges and bloomaries of Alabama have disappeared. Most of them were blown with the *trompe*, and the remainder with wooden "tubs."

It will be observed that as late as 1856 Alabama possessed a very small iron industry. During the civil war several new iron enterprises were undertaken. A furnace in Sanford county was built in 1861; Cornwall furnace, at Cedar Bluff, in

Cherokee county, was built in 1862; a second Shelby furnace, in Shelby county, was built in 1863; Alabama furnace, in Talladega county, was built in 1863, burned by General Wilson in April, 1865, and rebuilt in 1873. Two furnaces and a small rolling mill were built at Brierfield, in Bibb county, in 1863 and 1864. All of the furnaces were built to use charcoal. The Brierfield rolling mill was first used for rolling bar iron and rails. In 1863 or early in 1864 it was sold to the Confederate Government, by which it was operated until 1865, when it was burned by the Union troops under General Wilson. It was rebuilt after the war, and for some time was used to roll bar iron and cotton-ties, principally the latter. After having been idle for several years this mill is again in operation.

Since the close of the civil war the attention of Northern capitalists has been attracted to the large deposits of rich ores in Alabama, and several new furnaces, with modern improvements, have been built by them, some to use charcoal and others to use coke. Most of these furnaces are now in operation. Two new rolling mills have also been built in Alabama since the war—one at Helena, in Shelby county, built in 1872, and one at Birmingham, in Jefferson county, built in 1880.

The existence of bituminous coal in Alabama was first observed in 1834 by Dr. Alexander Jones, of Mobile, but little was done to develop the ample coal resources of the State until after the close of the civil war, when it was found that the coal in the neighborhood of Birmingham and at other places would produce excellent coke for blast furnaces, and that at least two coal fields—the Black Warrior and Coosa—were so extensive as to set at rest all apprehension concerning a constant supply of coal for a long period of time. These discoveries, joined to the possession of an abundant supply of good ores, at once gave Alabama prominence as a State which would before many years boast a large iron industry, and this promise is now being fulfilled. Birmingham is now the centre of the most extensive manufacture of coke pig iron in the Southern States. From 1880 to 1883 Alabama more than doubled its annual production of pig iron.

CHAPTER XXVII.

EARLY IRON ENTERPRISES IN OHIO.

The beginning of the iron industry of Ohio is cotemporary with the admission of the State into the Union. It was admitted in 1802, and in 1803 its first furnace, Hopewell, was commenced by Daniel Eaton, and in 1804 it was finished. The furnace stood on the west side of Yellow creek, about one and a quarter miles from its junction with the Mahoning river, in the township of Poland, in Mahoning county. On the same stream, about three-fourths of a mile from its mouth, and on the farm on which the furnace of the Struthers Furnace Company now stands, in the town of Struthers, another furnace was built in 1806 by Robert Montgomery and John Struthers. This furnace was called Montgomery. Thomas Struthers writes: "These furnaces were of about equal capacity, and would yield about two and a half or three tons each per day. The metal was principally run into moulds for kettles, bake-ovens, flat-irons, stoves, andirons, and such other articles as the needs of a new settlement required, and any surplus into pigs and sent to the Pittsburgh market." The ore was obtained in the neighborhood. Hopewell furnace is said by Mr. Struthers to have had a rocky bluff for one of its sides. It was in operation in 1807, but it was soon afterwards blown out finally. Montgomery furnace was in operation until 1812, when, Mr. Struthers says, "the men were drafted into the war, and it was never started again." This furnace stood "on the north side of Yellow creek, in a hollow in the bank." We are informed by Hon. John M. Edwards, of Youngstown, that about 1807 Hopewell furnace was sold by Eaton to Montgomery, Clendenin & Co., who were then the owners of Montgomery furnace, John Struthers having sold his interest in this furnace, or part of it, to David Clendenin in 1807, and Robert Alexander and James Mackey having about the same time become part owners.

The above-mentioned iron enterprises were the first in Ohio, and, as will be observed, they were both on the West-

ern Reserve. There were other early iron enterprises on the Reserve. At Nilestown, now Niles, in Trumbull county, as we are informed by Colonel Charles Whittlesey, of Cleveland, James Heaton built a forge in 1809, for the manufacture of bar iron from "the pig of the Yellow Creek furnace"—Montgomery furnace. "This forge produced the first hammered bars in the State." It continued in operation until 1838. About 1812 James Heaton built a furnace at Nilestown, near the mouth of Mosquito creek, where the Union school building now stands. It was called Mosquito Creek furnace. For many years it used bog ore, the product being stoves and other castings. It was in operation until 1856, when it was abandoned.

About 1816 Aaron Norton built a furnace at Middlebury, near Akron, in Summit county, and in 1819 Asaph Whittlesey built a forge on the Little Cuyahoga, near Middlebury. A furnace at Tallmadge, in the same county, was built about the same time. These two furnaces were in operation until about 1835.

The beginning of the iron industry in the counties on Lake Erie probably dates from 1828, when Arcole furnace was built in Madison township, in the present county of Lake, by Root & Wheeler. Concord furnace, in the same county, was built by Fields & Stickney about 1828. In 1830 John Wilkeson became the owner of Arcole furnace. Geauga furnace, one mile north of Painesville, in Lake county, and Railroad furnace, at Perry, in Geauga county, were built about 1828, the former by an incorporated company, and the latter by Thorndike & Drury, of Boston. During the next ten or twelve years several other furnaces were built near Lake Erie, in Ashtabula, Cuyahoga, Erie, Huron, and Lorain counties.

At a still later period other charcoal furnaces were built in the lake counties. All of these lake furnaces, writes John Wilkeson in 1858, "were blown some eight months each year, and made about 30 tons per week of metal from the bog ore found in swales and swamps near, and generally to the north of, a ridge of land which was probably once the shore of Lake Erie, found extending, with now and then an interval, along from the west boundary of the State of New York to the Huron river in Ohio. The want of wood for charcoal, consequent

upon the clearing up of the land, has occasioned the stoppage of most of these works. For a long time the settlers upon the shores of Lake Erie and in the State of Michigan were supplied with their stoves, potash-kettles, and other castings by these works."

All of the above-mentioned iron enterprises were on the Western Reserve. Just outside of its limits Gideon Hughes built a furnace in 1807 or 1808, on the Middle fork of Little Beaver creek, one and a half miles northwest of New Lisbon, in Columbiana county. It was in operation in 1808 and 1809. It was first called Rebecca of New Lisbon, but was afterwards named Dale furnace. Attached to this furnace a few years after its erection was a forge, which was used for making bar iron. Mr. John Frost, of New Lisbon, to whom we are indebted for this information, also writes us that "some two or three miles up the same stream Mr. Hughes and Joshua Malin erected a rolling mill in 1822, to which a company of Englishmen, said to be from Pittsburgh, not long afterwards added nail-making machinery. In addition to manufacturing bar iron, these works placed large quantities of nails in the market. This concern was more or less active till 1832, when the great flood of waters early in that year destroyed it, and it was never rebuilt." New Lisbon is located about twelve miles from the mouth of Little Beaver creek, which empties into the Ohio river.

Soon after the beginning of the iron industry on the Western Reserve the manufacture of iron was undertaken in some of the interior and southern counties of the State. Bishop says that Moses Dillon, who had been associated with Colonel Meason and John Gibson in the building of Union furnace, in Fayette county, Pennsylvania, in 1793, "afterwards erected a forge on Licking river, near Zanesville, Ohio, possibly the first in the State." This enterprise was preceded or immediately followed by a furnace, which is said to have been erected in 1808, but it may have been built a few years afterwards. It was located "at the Falls of Licking," four miles northwest of Zanesville, in Muskingum county, and its capacity was about one ton per day. It was used to produce castings, as well as pig iron for the forge. Lesley says that this furnace was not abandoned "until 1850 or later." The forge was also

operated until about 1850. The furnace and forge were known as Dillon's, and were widely celebrated.

Mary Ann furnace, ten miles northeast of Newark, in Licking county, was built about 1816 by Dr. Brice and David Moore. It was burned down about 1850. In Tuscarawas county the Zoar Community owned two early charcoal furnaces. One of these, called Tuscarawas, was built about 1830 by Christmas, Hazlett & Co., and was afterwards sold to the Community; the other, called Zoar, was built about the same time by the Community. Both furnaces were finally blown out before 1850.

Three furnaces were built in Adams county between 1811 and 1816. The first of these, Brush Creek, on the stream of that name, and twelve miles from the Ohio river, was operated in 1813 by James Rodgers. It was probably built in 1811, its builders being Andrew Ellison, Thomas James, and Archibald Paull. It was in operation as late as 1837, when it produced 200 tons of iron in 119 days. On the same stream, twenty-two miles from the Ohio, was Marble furnace, built in 1816. Another furnace, known as Old Steam, was built in 1814. This furnace is said to have been built by James Rodgers, Andrew Ellison, and the Pittsburgh Steam Engine Company. Thomas W. Means informs us that "the first blast furnace run by steam in Southern Ohio, if not in the United States, was built by James Rodgers in Adams county about 1814." This reference is to Old Steam furnace. "Its product was less than two tons of iron a day. Brush Creek furnace, in the same county, and other furnaces of that period which were run by water, hardly averaged one ton of iron a day." Marble and Old Steam furnaces were abandoned about 1826. Lesley mentions three forges in Adams county—Steam, at Old Steam furnace; Scioto, on the Little Scioto; and Brush Creek, probably connected with Brush Creek furnace. The date of the erection of these forges is not given, but they were doubtless built soon after the three Adams county furnaces. They were all abandoned many years ago. There is now no iron industry in Adams county.

In the chapter relating to Kentucky the beginning of the iron industry in the Hanging Rock region has been noted. This celebrated iron district embraces Greenup, Boyd, Carter,

and Lawrence counties in Kentucky, and Lawrence, Jackson, Gallia, and Vinton counties and part of Scioto county in Ohio. Just north of the Ohio portion of this district is the newly-developed Hocking Valley iron district, embracing Hocking and several other counties. The Hanging Rock district takes its name from a projecting cliff upon the north side of the Ohio river, situated back of the town of Hanging Rock, which is in Lawrence county, three miles below Ironton. The first furnace in the Ohio part of the Hanging Rock district was Union furnace, situated a few miles northwest of Hanging Rock, built in 1826 and 1827 by John Means, John Sparks, and James Rodgers, the firm's name being James Rodgers & Co. Franklin furnace was the second on the Ohio side. It stood sixteen miles east of Portsmouth, in Scioto county, and half a mile from the Ohio river, and was built in 1827 by the Rev. Daniel Young and others. The next furnace was Pine Grove, on Sperry's fork of Pine creek, back of Hanging Rock, in Lawrence county, and five miles from the Ohio river, built in 1828 by Robert Hamilton and Andrew Ellison. In the same year Scioto furnace, in Scioto county, fifteen miles north of Portsmouth, was built by William Salters. From this time forward blast furnaces increased rapidly on the Ohio side of the district, as well as on the Kentucky side. From 1826 to 1880 the whole number built on the Ohio side was about sixty, and on the Kentucky side about thirty. All of the early furnaces were built to use charcoal, but timber becoming scarce coke was substituted at some of them, while others were abandoned. In late years a few furnaces have been built in the district expressly to use coke or raw coal. In 1880 there were on the Ohio side thirty-one charcoal furnaces and seventeen bituminous coal or coke furnaces.

At Vesuvius furnace, on Storm's creek, in Lawrence county, Ohio, six miles northeast of Ironton, the hot-blast was successfully applied in 1836 by John Campbell and others, William Firmstone putting up the apparatus.

The Hanging Rock district, on both sides of the Ohio, has produced many eminent ironmasters, and its iron resources have been developed with great energy. Most prominent among its ironmasters of the generation now passing away are John Campbell, of Ironton, and Thomas W. Means, of

Hanging Rock. Mr. Campbell, who is a native of Brown county, Ohio, was born in 1808. In connection with others he has built eleven furnaces in the Hanging Rock district. He projected the town of Ironton and gave it its name, and also assisted in the founding of Ashland, Kentucky, and in building its railroad. Like most of the ironmasters of this district he is of Scotch-Irish extraction, his ancestors having removed in 1612 from Inverary, in Argyleshire, Scotland, to the neighborhood of Londonderry, in Ulster, Ireland. Their descendants removed in 1729 and 1739 to Augusta county, Virginia; thence, in 1790, to Bourbon county, Kentucky; and thence, in 1798, to that part of Adams county, Ohio, which is now embraced in Brown county. Mr. Means was born in South Carolina in 1803, and is also of Scotch-Irish origin. His father, John Means, was an owner of one of the furnaces and forges in Adams county, Ohio. He was born in Union district, South Carolina, on March 14, 1770, and moved to Adams county, Ohio, in 1819, taking with him his slaves, whom he liberated. He died on his farm near Manchester, in Adams county, on March 15, 1837, and was buried in the churchyard at Manchester. Andrew Ellison, Robert Hamilton, James Rodgers, and Andrew Dempsey, all now deceased, were enterprising and prominent iron manufacturers. In December, 1844, Mr. Hamilton successfully tried the experiment of stopping Pine Grove furnace, which he then owned, on Sunday, and his example has since been generally followed in the Hanging Rock region. This furnace is still active. John Campbell, Robert Hamilton, and Thomas W. Means were united in marriage with members of the Ellison family. The third generation of this family is now engaged in the iron industry of Southern Ohio.

In 1833 a forge was built at Hanging Rock, after which it was named, to manufacture blooms. It was owned by J. Riggs & Co., and was built under the superintendence of John Campbell and Joseph Riggs. A rolling mill was added before 1847. Both the forge and rolling mill have long been abandoned. A forge was built at Sample's Landing, fifteen miles below Gallipolis, soon after 1830, to make blooms for the Covington rolling mill. Bloom forge was built at Portsmouth, in Scioto county, in 1832, and in 1857 a rolling mill

was added. A forge called Benner's, on Paint creek, near Chillicothe, in Ross county, once owned by James & Woodruff, was abandoned about 1850. There never were many forges in Ohio for refining iron, and there have been few, if any, for making bar iron directly from the ore. The first iron enterprises in the State preceded by only a few years the building of rolling mills at Pittsburgh.

The first rolling mill at Cincinnati was the Cincinnati rolling mill, built about 1830 by Shreeve, Paull & McCandless. The Globe rolling mill was built at Cincinnati in 1845. Joseph Kinsey writes us that "it was the first built in Cincinnati for the purpose of making general sizes of merchant iron, hoops, sheets, and plates. It was built by William Sellers and Josiah Lawrence, and was considered a great enterprise at that time. Soon afterwards a wire mill was added for the purpose of making the first wire used for the lines of telegraph extending through this country." There are now in Cincinnati and in its vicinity on the Ohio side of the Ohio river five rolling mills, but no blast furnaces nor steel works.

Ohio is entitled to the honor of having had established within its boundaries the first successful works in the United States for the manufacture of *crucible steel of the best quality.* The proof of this claim is ample, and it will be presented in a subsequent chapter when we come to speak of this branch of our steel industry. The works alluded to were located on the bank of the Miami Canal, in Cincinnati, and were built in 1832 by two brothers, Dr. William Garrard and John H. Garrard, who were natives of England but residents of the United States after 1822. After the works were built William T. Middleton and Charles Fox were successively partners with Dr. Garrard, his brother having retired. Dr. Garrard was the inspiration of the enterprise, and its master spirit during the whole period of its existence. The firm failed in 1837, but the business was continued for some time afterwards. During the first five years the best crucible steel was made at these works by Dr. Garrard, entirely with American materials. It was used for saws, springs, axes, reaper knives, files, and tools generally. Dr. Garrard is still living at an advanced age at Fallston, in Beaver county, Pennsylvania, and it affords us a great deal of pleasure to rescue from threatened oblivion, and

in the Doctor's lifetime, the details hereafter to be presented of his honorable connection with one of the most interesting episodes in the history of our iron and steel industries.

The foregoing details relate to what may be termed the charcoal era of the Ohio iron industry. The second stage in the development of the iron industry of this State dates from the introduction in its blast furnaces of the bituminous coal of the Mahoning valley in its raw state. This coal is known as splint coal, or block coal, or as Brier Hill coal, from a locality of that name near Youngstown, where it is largely mined. The first furnace in Ohio to use the new fuel was built expressly for this purpose at Lowell, in Mahoning county, in 1845 and 1846, by Wilkeson, Wilkes & Co., and it was successfully blown in on the 8th of August, 1846. The name of this furnace was at first Anna and afterwards Mahoning. A letter from John Wilkeson, now of Buffalo, New York, informs us that William McNair, a millwright, was the foreman who had charge of its erection. It was blown in by John Crowther, who had previously had charge of the furnaces of the Brady's Bend Iron Company, at Brady's Bend, Pennsylvania.

Mr. Wilkeson and his brothers had for many years been prominent charcoal-iron manufacturers on the Western Reserve. They are of Scotch-Irish extraction. Their father was a native of Carlisle, Pennsylvania.

Immediately after the successful use of uncoked coal in the furnace at Lowell many other furnaces were built in the Mahoning valley to use the new fuel, and it was also substituted for charcoal in some old furnaces. At a later day the use of this fuel in other parts of Ohio contributed to the further development of the manufacture of pig iron in this State, and at a still later and very recent date the opening of the extensive coal beds of the Hocking valley and the utilization of its carbonate ores still further contributed to the same development.

The proximity of the coal fields of Ohio to the rich iron ores of Lake Superior has been a very important element in building up the blast-furnace industry of the State. The use of these ores in Ohio soon followed the first use in the blast furnace of the block coal of the Mahoning valley. An in-

crease in the rolling-mill capacity of Ohio was naturally coincident with the impetus given to the production of pig iron by the use of this coal and Lake Superior ores. David Tod, afterwards Governor of Ohio, bore a prominent part in the development of the coal and iron resources of the Mahoning valley.

The beginning of the iron industry at Youngstown, which now has within its own limits or in the immediate vicinity thirteen furnaces and six rolling mills, dates from about 1835, when a charcoal furnace called Mill Creek was built on a creek of the same name, a short distance southwest of the city, by Isaac Heaton, a son of James Heaton. There was no other furnace at Youngstown until after the discovery at Lowell that the block coal of the Mahoning valley could be successfully used in the smelting of iron ore. In a recent sketch of the history of Youngstown Hon. John M. Edwards says: "In 1846 William Philpot & Co. built in the northwestern part of Youngstown, adjoining the present city, and near the canal, the second furnace in the State for using raw mineral coal as fuel. In the same year a rolling mill was built in the southeastern part of the village, and adjoining the canal, by the Youngstown Iron Company. This mill is now owned by Brown, Bonnell & Co." In a sketch of *Youngstown, Past and Present*, printed in 1875, a fuller account is given of the first bituminous furnace at that place. It was known as the Eagle furnace, and was "built in 1846 by William Philpot, David Morris, Jonathan Warner, and Harvey Sawyer, on land purchased of Dr. Henry Manning, lying between the present city limits and Brier Hill. The coal used was mined from land contiguous, leased from Dr. Manning." The second furnace at Youngstown to use raw coal was built in 1847 by Captain James Wood, of Pittsburgh. It was called Brier Hill furnace.

The iron industry of Cleveland has been built up during recent years, and the city is now one of the most prominent centres of iron and steel production in the country. Charles A. Otis, of Cleveland, writes us as follows concerning the first rolling mills in that city: "The first rolling mill at Cleveland was a plate mill, worked on a direct ore process, which was a great failure. It went into operation in 1854 or 1855.

The mill is now owned by the Britton Iron and Steel Company. The next mill was built in 1856 by A. J. Smith and others to re-roll rails. It was called Railroad rolling mill, and is now owned by the Cleveland Rolling Mill Company. At the same time a man named Jones, with several associates, built a mill at Newburgh, six miles from Cleveland, also to re-roll rails. It was afterwards operated by Stone, Chisholm & Jones, and is now owned by the Cleveland Rolling Mill Company. In 1852 I erected a steam forge to make wrought-iron forgings, and in 1859 I added to it a rolling mill to manufacture merchant bar, etc. The Union rolling mills were built in 1861 and 1862 to roll merchant bar iron." There are now in Cleveland eight rolling mills and steel works and six blast furnaces, as well as several iron and steel establishments of a reproductive character.

In the list of persons connected with the development of the iron and steel industries of Cleveland the name of Henry Chisholm is the most prominent. Mr. Chisholm was born at Lochgelly, in Fifeshire, Scotland, on April 27, 1822, and died at Cleveland on May 9, 1881, aged 59 years.

From 1846 to 1884 the iron industry of Ohio has made steady progress, and the State now ranks second among the iron-producing States of the Union. This was also its rank in 1870 and in 1880.

CHAPTER XXVIII.

EARLY IRON ENTERPRISES IN INDIANA.

INDIANA possessed a small charcoal-iron industry before 1850, but at what period in the present century this industry had its beginning can not now be definitely determined. Tench Coxe makes no reference to it in 1810, but mentions one nailery in the Territory, which produced in that year 20,000 pounds of nails, valued at $4,000. He does not locate this enterprise. In 1840 the census mentions a furnace in Jefferson county, one in Parke, one in Vigo one in Vermillion, and three in Wayne county, the total product being only 810 tons of "cast iron." A forge in Fulton county, producing 20 tons of "bar iron," is also mentioned. The census of 1840, however, frequently confounds furnaces with foundries, and it is therefore possible that some of the alleged furnaces in Indiana at that period were foundries. The Fulton county forge was probably only a bloomary.

In 1859 Lesley enumerated five charcoal furnaces in Indiana, as follows: Elkhart, in Elkhart county, date of erection unknown; La Porte, near the town of that name, in La Porte county, built in 1848; Mishawaka, in Saint Joseph county, built about 1833; Richland, on Richland creek, in Greene county, built in 1844 by A. Downing; and Indiana, a few miles northwest of Terre Haute, in Vigo county, built in 1839. The three last named were in operation in 1857, but were abandoned about 1860. Elkhart and La Porte furnaces were idle in 1857, and probably had been abandoned at that time. Elkhart, La Porte, and Mishawaka used bog ore exclusively, and Richland used it in part; in 1857 Mishawaka was still using it. Indiana furnace used brown hematite found in the neighborhood. In a chapter on the geology of Monroe county, by George K. Greene, printed in 1881, it is stated that "nearly forty years ago an iron furnace was erected by Randall Ross, of Virginia, on the lands of George Adams, of Monroe county, on section 7, township 7, range 2 west. The investment soon proved a failure, and the furnace

has long gone to decay. The ruins of the 'old iron furnace' are to-day the mournful monument of an early spirit of enterprise that deserved a better fate." The early Indiana furnaces doubtless made more castings than pig iron.

In 1860 there was only one furnace in blast in Indiana—Richland. It was abandoned probably in that year, and from this time until 1867 no pig iron was made in Indiana. In the latter year the manufacture of pig iron in this State was revived, the development of the block-coal district in the neighborhood of Brazil, in Clay county, having led to the belief that this fuel might be profitably used in blast furnaces. Planet furnace, at Harmony, in Clay county, built in the summer of 1867, and put in blast in November of that year, was the first of eight furnaces that were built in Indiana between 1867 and 1872 to use this coal, the ores for the furnaces being mainly obtained from Missouri and the Lake Superior district of Michigan. Five of these furnaces were in Clay county. Of the eight furnaces built five have been abandoned and torn down since 1872, and of the remaining three one has been using charcoal and two are using block coal. No furnaces have been built in Indiana since 1872.

Except the solitary forge we have mentioned above as existing in Fulton county in 1840, and then active, we have no record of any forges or bloomaries having been built in Indiana at any period. The first rolling mill in the State was probably the Indianapolis mill, built by R. A. Douglas, which was completed in the autumn of 1857, and put in operation in November of the same year. Lesley in 1858 says: "The machinery and building were planned by Lewis Scofield, of Trenton, New Jersey, who also built the Wyandotte mill and is building the mill at Atlanta, Georgia." There were in 1883 eight rolling mills in Indiana—two at New Albany, two at Terre Haute, and one each at Indianapolis, Greencastle, Aurora, and Brazil. The State contained no works in that year for the manufacture of steel, nor has it had any works of this kind at any time.

CHAPTER XXIX.

EARLY IRON ENTERPRISES IN ILLINOIS.

In 1839 a small charcoal furnace was built four miles northwest of Elizabethtown, in Hardin county, in the extreme southeastern part of Illinois, by Leonard White, Calen Guard & Co. It was called Illinois. This is the first furnace in the State of which there is any record, and it probably had no predecessor. In 1853 it was purchased by C. Wolfe & Co., of Cincinnati, who tore down the stack and built a larger one in 1856, with modern additions. In 1873 this furnace, after having been out of blast for several years, was repaired, but it has not since been put in blast. A charcoal furnace called Martha, also in Hardin county, was built in 1848 by Daniel McCook & Co., about two miles east of Illinois furnace. It was probably the second furnace in the State. Illinois and Martha furnaces were both in blast in 1850, but in 1860 only Illinois was in blast. Martha had not been in operation since 1856, and it probably never made any iron after that year. It has long been abandoned. These furnaces were supplied with limestone ore from the immediate neighborhood.

In the census of 1840 mention is made of a furnace in Cook county, one in Fulton, one in Hardin, and one in Wabash county. The furnaces in Fulton and Hardin counties were idle, the furnace in Wabash county produced eight tons of "cast iron," and the furnace in Cook county produced 150 tons. As the census of 1840 frequently confounds blast furnaces with foundries, reliance can not be placed on the correctness of its statements concerning furnaces in Illinois. We have definitely ascertained that there was no furnace in Cook county in that year, and that the furnace with which it is credited in the census was Granger's foundry, the only one in Chicago at that time.

There appears to have been no furnace in operation in Illinois from 1860 to 1868. Soon after the close of the civil war the attention of iron manufacturers was attracted to the Big Muddy coal fields, in the southwestern part of Illinois,

and to the proximity to these coal fields of the rich iron ores of Missouri. In 1868 the Grand Tower Mining, Manufacturing, and Transportation Company built two large furnaces at Grand Tower, in Jackson county, Illinois, to use the Big Muddy coal in connection with Missouri ores; and in 1871 another large furnace, called Big Muddy, was built at Grand Tower, by another company, to use the same fuel and ores. The two Grand Tower furnaces have been out of blast for several years and are now abandoned, but the Big Muddy furnace was in blast in 1881. At East Saint Louis the Meier Iron Company built two large coke furnaces between 1873 and 1875. These furnaces were in operation in 1882, their fuel being mainly Carbondale coke, from Jackson county, Illinois.

The iron industry at Chicago and in its vicinity properly dates from 1857, when Captain E. B. Ward, of Detroit, built the Chicago rolling mill, on the right bank of the Chicago river, "just outside of the city." This mill was built to reroll iron rails. It formed the nucleus of the present very extensive works of the North Chicago Rolling Mill Company. There was no furnace at Chicago until 1868, when two furnaces were built by the Chicago Iron Company. They are now owned by the Union Steel Company. One furnace was blown in early in 1869, and the other late in the same year. Two furnaces were built at Chicago in 1869 by the North Chicago Rolling Mill Company. No other furnaces were built at Chicago until 1880, when seven new furnaces were undertaken, three of which were finished in that year, two in 1881, and two in 1882. At Joliet, thirty-seven miles southwest of Chicago, the Joliet Iron and Steel Company built two furnaces in 1873. They are now owned by the Joliet Steel Company.

In 1883 there were seventeen rolling mills and steel works in Illinois, four of which were Bessemer steel works—three at Chicago and one at Joliet; two were open-hearth steel works—one at Springfield and one at Chicago; and one was a crucible steel works at Chicago. At the beginning of 1884 there were seventeen blast furnaces in the State, including the pioneer furnace, Illinois. In 1880 Illinois ranked fourth among the iron and steel producing States of the Union, making a great stride since 1870, when it was fifteenth in rank.

CHAPTER XXX.

EARLY IRON ENTERPRISES IN MICHIGAN.

If we could credit the census of 1840 there were fifteen blast furnaces in Michigan in that year—one in each of the counties of Allegan, Branch, Cass, Kent, Monroe, and Oakland, two in Calhoun, two in Washtenaw, and five in Wayne county. Some of these alleged furnaces were doubtless foundries, particularly in counties lying upon or near to Lake Erie, vessels upon which could bring pig iron for these foundries from neighboring States. Others were undoubtedly true blast furnaces, producing household and other castings from bog ores. All of the fifteen enterprises mentioned were in the southern part of the State. Their total production in 1840 was only 601 tons of "cast iron." Neither forges nor bloomaries are mentioned in the census of 1840.

From 1840 to 1850 the iron industry of Michigan certainly made no progress, and possibly declined. From 1850 to 1860 a marked improvement took place. Three new furnaces were built in the southern part of the State to use bog ore, and in the northern peninsula and at Detroit and Wyandotte a commencement was made in smelting the rich ores which had been discovered in the now celebrated Lake Superior iron-ore region. In 1859 Lesley enumerated the following bog-ore furnaces in the southern part of the State: Kalamazoo, at the city of that name, in Kalamazoo county, built in 1857 to take the place of an earlier furnace; Quincy, three miles north of the town of that name, in Branch county, built in 1855; and Branch County, one mile from Quincy furnace, built in 1854. All of these bog-ore furnaces made pig iron in 1857. It is a curious fact that furnaces to use bog ore should have been built in this State after 1850.

The development of the Lake Superior iron-ore region marks an important era in the history of the American iron trade, and the incidents attending its commencement have fortunately been preserved.

We learn from A. P. Swineford's *History of the Lake Supe-*

rior Iron District that the existence of iron ore on the southern border of Lake Superior was known to white traders with the Indians as early as 1830. The same writer further informs us that the first discovery by white men of the iron ore of this region was made on the 16th of September, 1844, near the eastern end of Teal lake, by William A. Burt, a deputy surveyor of the General Government. In June, 1845, the Jackson Mining Company was organized at Jackson, Michigan, for the purpose of exploring the mineral districts of the southern shore of Lake Superior, and in the summer of the same year this company, through the disclosures of a half-breed Indian, named Louis Nolan, and the direct agency of an old Indian chief, named Man-je-ki-jik, secured possession of the now celebrated Jackson iron mountain, near the scene of Mr. Burt's discovery. It appears, however, that the representatives of the company had not heard of Mr. Burt's discovery until they met Nolan and the Indian chief. P. M. Everett, the president of the company, was the leading spirit of the exploring party which secured possession of this valuable property. The actual discovery of Jackson mountain was made by S. T. Carr and E. S. Rockwell, members of Mr. Everett's party, who were guided to the locality by the Indian chief.

In a letter written on the 10th of November, 1845, at Jackson, Michigan, Mr. Everett, referring to the ore of Jackson mountain, says that "since coming home we have had some of it smelted, and find that it produces iron and something resembling gold—some say it is gold and copper." This smelting is not further described. In 1846 A. V. Berry, one of the Jackson Mining Company, and others, brought about 300 pounds of the ore to Jackson, and in August of that year, writes Mr. Berry, "Mr. Olds, of Cucush Prairie, who owned a forge, then undergoing repair, in which he was making iron from bog ore, succeeded in making a fine bar of iron from our ore in a blacksmith's fire—the first iron ever made from Lake Superior ore." Mr. Swineford says that "one end of this bar of iron Mr. Everett had drawn out into a knife-blade."

In 1847 the Jackson Mining Company commenced the erection of a forge on Carp river, about ten miles from its mouth, and near Jackson mountain. It was finished early

in 1848, and on the 10th of February of that year the first iron made in the Lake Superior region was made at this forge by Ariel N. Barney. Mr. Swineford says that the forge, which was named after Carp river, had "eight fires, from each of which a lump was taken every six hours, placed under the hammer, and forged into blooms four inches square and two feet long, the daily product being about three tons. The first lot of blooms made at this forge—the first iron made on Lake Superior, and the first from Lake Superior ores, except the small bar made by Mr. Olds—was sold to the late E. B. Ward, and from it was made the walking-beam of the side-wheel steamer *Ocean*." The forge was kept in operation until 1854, when it was abandoned, having in the mean time "made little iron and no money."

In 1849 the Marquette Iron Company, a Worcester (Massachusetts) organization, undertook the erection of a forge at Marquette, and in July, 1850, it was finished and put in operation. Mr. Swineford says that "it started with four fires, using ores from what are now the Cleveland and Lake Superior mines." It was operated irregularly until December, 1853, when it was burned down and was not rebuilt.

The Collins Iron Company was organized in 1853, with Edward K. Collins, of New York, at its head, and in 1854 it built a forge on Dead river, about three miles northwest of Marquette, and in the fall of 1855 the manufacture of blooms was commenced from ore obtained at the company's mines. This forge was in operation in 1858, after which time it seems to have been abandoned.

Another forge on Dead river was built in 1854 or 1855 by William G. McComber, Matthew McConnell, and J. G. Butler. The company failed in a few years, and in 1860 Stephen R. Gay erected Bancroft furnace on the site of the forge. Before 1860 every forge in Michigan appears to have been abandoned.

It will be observed that all of the first iron enterprises in the Lake Superior district were bloomary forges, the intention evidently having been to build up an iron industry similar to that of the Lake Champlain district.

The first pig iron produced in the Lake Superior region was made in 1858 by Stephen R. Gay, who then leased the

forge of the Collins Iron Company and converted it in two days, at an expense of $50, into a miniature blast furnace. Mr. Gay writes to C. A. Trowbridge that this furnace was "2½ feet across the bosh, 8 feet high, and 12 inches square at the top and 15 inches square in the hearth," and would hold eight bushels of coal. He gives the following details of its first and only blast: "Began on Monday, finished and fired on Wednesday, filled with coal Thursday noon, blast turned on Friday noon, and thenceforth charged regularly with 1 bushel coal, 20 pounds of ore, and 7 pounds of limestone. Cast at six o'clock 500 pounds, and again at eight o'clock Saturday morning, half a ton in all, 92 pounds of which were forged by Mr. Eddy into an 85-pound bloom. This little furnace was run two and a half days, made 2½ tons, carrying the last eight hours 30 pounds of ore to a bushel of coal, equal to a ton of pig iron to 100 bushels of coal." These experiments were made in February.—These particulars we find in the records of The American Iron and Steel Association.

The first regular blast furnace in the Lake Superior region was built by the Pioneer Iron Company in the present city of Negaunee, convenient to the Jackson mine. It was commenced in June, 1857, and in February, 1858, it was finished. Another stack was added in the same year. These furnaces took the name of the company. Pioneer No. 1 was put in blast in April, 1858, and Pioneer No. 2 on May 20, 1859. Both furnaces are now owned by the Iron Cliffs Company, and both were in operation in 1883. The second regular blast furnace in this region was the Collins furnace, built in 1858 by Stephen R. Gay, near the site of the Collins forge. It made its first iron on December 13th of that year. It was abandoned in 1873, owing to the failure of a supply of charcoal. Other furnaces in the Lake Superior region soon followed the erection of the Pioneer and Collins furnaces. Mr. Swineford's history contains a record of them.

While these early furnaces and the few forges that have been mentioned were being built on the shore of Lake Superior two furnaces were built at or near Detroit to smelt Lake Superior ores. These were the Eureka furnace, at Wyandotte, built in 1855 by the Eureka Iron Company, of which Captain E. B. Ward was president, and put in blast in 1856; and the

Detroit furnace, at Detroit, built in 1856 by the Detroit and Lake Superior Iron Manufacturing Company, of which George B. Russell was president, and put in blast in January, 1857. These furnaces and the others that have been mentioned used charcoal as fuel.

The first shipment of iron ore from the Lake Superior region was made in 1850, according to Mr. Swineford, and consisted of about five tons, "which was taken away by Mr. A. L. Crawford, of New Castle, Pennsylvania." A part of this ore was reduced to blooms and rolled into bar iron. "The iron was found to be most excellent, and served to attract the attention of Pennsylvania ironmasters to this new field of supply for their furnaces and rolling mills." In 1853 three or four tons of Jackson ore were shipped to the World's Fair at New York.

The first use of Lake Superior ore in a blast furnace occurred in Pennsylvania. The important event is described in a letter to us from the late David Agnew, of Sharpsville, Mercer county, Pennsylvania, from which we quote as follows:

> The Sharon Iron Company, of Mercer county, Pennsylvania, about the year 1850 or 1851 purchased the Jackson mines, and, in expectation of the speedy completion of the Sault canal, commenced to open them, to construct a road to the lake, and to build docks at Marquette, expending a large sum of money in these operations. The opening of the canal was, however, unexpectedly delayed until June, 1855. Anxious to test the working qualities of this ore, the Sharon Iron Company brought, at great expense, to Erie, in the year 1853, about 70 tons of it, which was shipped by canal to Sharpsville furnace, near Sharon, owned by David and John P. Agnew. The first boat-load of ore, on its receipt, was immediately used in the furnace, partly alone and partly in mixture with native ores, and the experiment was highly successful, the furnace working well and producing an increased yield of metal, which was taken to the Sharon iron works and there converted into bar iron, nails, etc., of very superior quality. The second boat-load of ore was also brought to Sharpsville, but, having been intended to be left at the Clay furnace, owned by the Sharon Iron Company, was returned and used at that establishment.

In 1854, 1855, and 1856 Clay furnace continued the use of Lake Superior ore, most of it mixed with native ore, and used in all until August, 1856, about 400 tons. "Up to that date," as is stated by Mr. Frank Allen, its manager, "the working of it was not a success. In October, 1856, we gave the Clay furnace a general overhauling, put in a new lining and hearth,

and made material changes in the construction of the same, put her in blast late in the fall, and in a few days were making a beautiful article of iron from Lake Superior ore alone." The fuel used at Sharpsville and Clay furnaces was the block coal of the Shenango valley. After 1856 other furnaces in Pennsylvania and in other States began the regular use of Lake Superior ore.

David Agnew was born at Frankstown, in Blair county, Pennsylvania, on September 25, 1805, and died at Sharpsville, in Mercer county, on August 24, 1882, aged almost 77 years. His whole life was devoted to the manufacture of iron.

Until about 1877 the mining of iron ore in the Lake Superior region was confined to the territory in the immediate vicinity of Marquette. Since 1877, and particularly since 1879, a new iron-ore region has been developed in the northern part of Menominee county and the southern part of Marquette county, in Michigan, and in Florence county, Wisconsin. It is called the Menominee Range district. This region has proved to be very productive and the ore to be very pure.

Since the discovery of iron ore in the Lake Superior region there have been built on the upper peninsula, in the vicinity of the mines, twenty-five furnaces, of which thirteen have been abandoned. There have also been built at other points in Michigan, to use Lake Superior ore, sixteen furnaces, of which none had been abandoned in 1883. All of these furnaces, with the exception of two at Marquette, were built to use charcoal, and the abandonment of many of them in the upper peninsula is attributable to the scarcity of timber for fuel. Michigan is, however, the first State in the Union to-day in the manufacture of charcoal pig iron, having twenty-eight furnaces, of which all but one furnace at Marquette now use charcoal exclusively when in operation. The three bog-ore furnaces in Kalamazoo and Branch counties have been abandoned.

There are now three active rolling mills in Michigan—the Eureka, formerly the Wyandotte, at Wyandotte, built in 1855; the rolling mill of the Baugh Steam Forge Company, at Detroit, built in 1877, the forge having been built in 1870; and the works of the Detroit Steel and Spring Company, at Detroit, which has recently commenced the manufacture of cru-

cible steel. In 1871 a rolling mill was built at Marquette, which has since been abandoned. In 1872 a rolling mill was built at Jackson, in Jackson county, but it was torn down in 1879, and the machinery removed to the mill of the Springfield Iron Company, at Springfield, Illinois.

From the Marquette *Mining Journal*, edited by Mr. Swineford, we take the following statement of the aggregate production of the Lake Superior iron-ore mines for each calendar year since the commencement of mining operations in the district.

Year.	Gross tons.	Year.	Gross tons.	Year.	Gross tons.
1856 and previous...	86,319	1866...	296,713	1876...	993,311
1857...	25,646	1867...	465,504	1877...	1,025,129
1858...	22,876	1868...	510,522	1878...	1,125,093
1859...	68,832	1869...	639,097	1879...	1,414,182
1860...	114,401	1870...	859,507	1880...	1,987,598
1861...	114,258	1871...	813,984	1881...	2,321,315
1862...	124,169	1872...	948,553	1882...	2,948,307
1863...	203,055	1873...	1,195,234	1883...	2,352,889
1864...	247,059	1874...	935,488		
1865...	193,758	1875...	910,840	Total...	22,943,639

The iron ores of Lake Superior that are not used in Michigan are mainly shipped to Ohio, Pennsylvania, Illinois, and Wisconsin. About one-third of all the pig iron that is now manufactured in the United States is made from these ores.

Captain Ward was the most prominent of all the iron manufacturers of Michigan, his enterprise in this respect extending to other States than his own.

In 1870 Michigan ranked eighth in the list of iron-producing States, and in 1880 its rank was the same.

CHAPTER XXXI.

THE EARLY MANUFACTURE OF IRON IN WISCONSIN.

In 1840 the census mentions a furnace in "Milwaukee town," which produced three tons of iron in that year. This was doubtless a small foundry. In 1859 Lesley mentions three charcoal furnaces in Wisconsin—Northwestern, or Mayville, at Mayville, in Dodge county, forty miles northwest of Milwaukee, and five miles from the Iron ridge, built in 1853 by the owners of Mishawaka furnace in Indiana, and to which a foundry was added in 1858; Ironton, at Ironton, in Sauk county, built in 1857 by Jonas Tower; and Black River, built in 1857 by a German company on the east bank of Black river, near the falls, in German county. Of these furnaces at least one, Ironton, was built to produce castings. A description of it in 1858 says: "It is a small blast furnace capable of producing about three tons of iron per day, and intended for the manufacture of stoves, castings, etc." The Ironton furnace has recently produced castings as well as pig iron. The Mayville furnace is still in operation, having been rebuilt in 1872, but the Black River furnace has long been abandoned. There appear to have been neither forges nor bloomaries in Wisconsin in 1840, 1850, or 1860.

The furnaces which have been mentioned were all that the State could boast until 1865, when a charcoal furnace at Iron Ridge, in Dodge county, was built by the Wisconsin Iron Company. This was soon followed by several other furnaces, some of which were built to use native ores and some to use Michigan ores from Lake Superior. The Appleton Iron Company built two furnaces at Appleton, in Outagamie county, in 1871 and 1872; C. J. L. Meyer built a furnace at Fond du Lac in 1874, but it was not put in blast until the summer of 1883; the Fox River Iron Company built two furnaces at West De Pere, in Brown county, in 1869 and 1872; the Green Bay Iron Company built a furnace at Green Bay, in the same county, in 1870; and the National Furnace Company built two furnaces at De Pere, in the same county, in 1869 and 1872.

All of these furnaces were built to use charcoal. In 1870 and 1871 the Milwaukee Iron Company built two large furnaces at Bay View, near Milwaukee, and in 1873 the Minerva Iron Company built a furnace at Milwaukee. These three furnaces were built to use mineral fuel and Lake Superior ores. A furnace called Richland was built in 1876 at Cazenovia, in Richland county, but was torn down in 1879. In 1883 there were fifteen furnaces in the State, twelve of which used charcoal and three used anthracite coal and coke.

Wisconsin had no rolling mill until 1868, when its first and thus far its only mill was built at Milwaukee by the Milwaukee Iron Company, of which Captain E. B. Ward was a leading member. This was from the first a large mill. It was built to re-roll iron rails, but soon commenced the manufacture of new rails. In 1874 a merchant bar mill was added, and in 1883 a nail mill was added. This mill and the two Bay View furnaces are now operated by the North Chicago Rolling Mill Company.

Within the last few years the mining of iron ore in Florence county, Wisconsin, immediately west of the Menominee district in Michigan, has been prosecuted with much activity. In 1882 there were produced in this county 276,017 tons of iron ore.

Wisconsin advanced rapidly in the manufacture of iron in the decade between 1870 and 1880. In the latter year it ranked sixth among the iron-producing States of the Union. In 1870 it was twelfth in rank.

CHAPTER XXXII.

EARLY IRON ENTERPRISES IN MISSOURI.

MISSOURI has an iron history which antedates its admission into the Union in 1820. The celebrated iron district, in Iron and Saint Francois counties, which embraces Iron Mountain and Pilot Knob, contained a blast furnace before 1819, and possibly as early as 1812 or 1814, as we find in a prospectus of the Missouri Iron Company, written in 1837, the statement that "cannon balls, made from the Iron Mountain ore during the late war, after having been exposed for several years to the open atmosphere and rains, still maintained their original metallic lustre." The cannon balls referred to would probably be used in the defense of New Orleans. This furnace was called Springfield, and was situated in the vicinity of Iron Mountain, and about forty miles from the Mississippi river, but its exact location we can not learn. It was in Washington county, as the county was then bounded. In 1858 Lesley says that "an old charcoal furnace was once in operation in township 33, range 4 north, half section 2" of Iron county. This may have been Springfield furnace. John Perry and Colonel Ruggles, whether jointly or severally the authority from which we quote does not state, operated Springfield furnace "for more than fifteen years" prior to 1837. In that year the furnace was in operation, when it was called "a small furnace." A forge was then attached to it, and "a blooming forge" was promised "the ensuing year."

Maramec furnace, in Phelps county, about sixty miles west of Iron Mountain, was finished in 1829, and rebuilt many years afterwards. It was probably commenced in 1826, as in that year the ore banks in the vicinity were opened by Massey & James. It is still standing but not in operation. At an early day a forge was added to the furnace, to convert its pig iron into bar iron, and this forge, with eight fires, is also still standing but not in operation, its product when last employed being charcoal blooms. In 1843 a rolling mill was added, but it was "abandoned after one year's trial, because of the

sulphur in the stone coal obtained at a bank fourteen miles southeast."

In the census of 1840 Missouri is credited with two furnaces—one in Crawford county, and one in Washington county. It is also credited with three forges in Crawford county and one in Washington county. The furnace in Crawford county was Maramec—Phelps county not having been then organized, and the forges in Crawford county were probably attached to Maramec furnace. The furnace in Washington county was Springfield, and the forge was doubtless the one attached to this furnace. We do not hear of Springfield furnace and forge after this time.

In 1836 the remarkable iron-ore mountains already mentioned—Iron Mountain and Pilot Knob—attracted the attention of some Missouri capitalists, and in the fall of that year the Missouri Iron Company, with a nominal capital of $5,000,000, was formed to utilize their ores, the legislature chartering the company on December 31, 1836. In January, 1837, the company was fully organized under the presidency of Silas Drake, of Saint Louis, who was soon succeeded by J. L. Van Doren, of Arcadia, but active work in the development of its property does not appear to have been undertaken until some years afterwards, when a few furnaces were erected at the foot of the mountains by other companies. In 1846 a furnace was built at the southwest base of Little Iron Mountain, which was followed in 1850 by another furnace at the same place, and in 1854 by still another. In 1849 a furnace was built on the north side of Pilot Knob, which was followed in 1855 by another at the same place. These were all charcoal furnaces, and were exceptionally well managed in 1857, when they were visited and described by Charles B. Forney, of Lebanon, Pennsylvania. At that time two of the Iron Mountain furnaces and one of the Pilot Knob furnaces used hot-blast.

In 1846 Moselle furnace was built at Moselle, in Franklin county, and in 1859 a furnace was built at Irondale, in Washington county—both furnaces to use charcoal. These, with the furnaces previously mentioned, appear to have been all that were built in Missouri prior to 1860.

The iron industry of Saint Louis appears to have had its commencement in 1850, when the Saint Louis, or Laclede,

rolling mill was built. It was followed by the Missouri rolling mill, built in 1854; by the Allen rolling mill, built in 1855; by the Pacific rolling mill, built in 1856; and by Raynor's rolling mill, built in 1858. In 1880 there were seven rolling mills in Saint Louis, and there were no others in Missouri. One of these mills, the Vulcan, built in 1872, was connected with the Bessemer steel works of the Vulcan Steel Company, and rolled steel rails. Two other mills rolled light iron rails and bar iron. In 1883 there was one rolling mill less than in 1880. The Bessemer works of the Vulcan Steel Company were built in 1875 and 1876. They are now owned by the Saint Louis Ore and Steel Company. The State had no other steel works in 1883.

Saint Louis had no blast furnaces until 1863, when the Pioneer furnace was built at Carondelet, to use coke. It was in blast in 1873, but in 1874 it was torn down and removed by the Pilot Knob Iron Company. In 1869 the Vulcan Iron Works, now the Saint Louis Ore and Steel Company, built two furnaces, which were followed in 1872 by another furnace built by the same company. In 1870 and 1872 the South Saint Louis Iron Company built two furnaces; in 1870 the Missouri Furnace Company built two; and in 1873 Jupiter furnace was built, but it was not put in blast until 1880. These eight furnaces were all built to use Illinois or Connellsville coke and Missouri ores.

In 1871 a large forge, called the Germania iron works, was built at South Saint Louis, to make charcoal blooms from pig iron, but it has been idle for several years. In 1873 a forge was built at Kimmswick, in Jefferson county, which was enlarged and remodeled in 1877 by the Peckham Iron Company, its product after the enlargement being charcoal blooms direct from the ore. It was in operation in 1883.

In 1883 there were nine charcoal furnaces and eight coke furnaces in Missouri. From 1870 to 1880 the iron industry of Missouri was subject to exceptional vicissitudes, and in the latter year it lost the prominent rank it held among iron-producing States in 1870. It then ranked sixth, but in 1880 it had fallen to the tenth place. The shipments of iron ore from Missouri to other States for many years averaged over 100,000 tons annually, but they have now declined.

CHAPTER XXXIII.

THE MANUFACTURE OF IRON IN VARIOUS WESTERN STATES AND IN THE TERRITORIES.

MINNESOTA has one furnace, situated at Duluth, which was commenced in 1873 and not finished until 1880, when it was put in blast. Its projectors failed, and after passing through the hands of creditors it was purchased by the Duluth Iron Company, its present owner. It uses charcoal as fuel, and obtains its supply of ore from the Lake Superior mines in Michigan. A small rolling mill has just been built at Minneapolis. The Minnesota Iron Company is opening in 1884 valuable iron ore deposits in the Vermillion district of Saint Louis county, Minnesota. The ore of this district possesses the same general characteristics as that of Northern Michigan.

In 1857 a bloomary called Big Creek was built about six miles southwest of Smithville, in Lawrence county, Arkansas, by Alfred Bevens & Co. In 1858 Lesley describes it as "a bloomary with two fires and a hammer, making 250 pounds of swedged iron per day per fire, with a cold-blast in November, 1857, but has now a hot-blast, and is making perhaps 800 pounds, using 300 bushels of charcoal to the ton of finished bars, made out of brown hematite ore." The bloomary was driven by water-power. It is not mentioned in the census of 1860 or 1870, and has been abandoned. Mr. Clarke W. Harrington, of Berryville, Carroll county, writes us that in 1850 an Englishman named Abram Beach built a bloomary in this county, which was in operation for a few years, when it was swept away by a freshet. It was succeeded by the "Higgins grist mill." The hammer used at this bloomary may now be seen on its site. Mr. Harrington says that "Beach made a large number of plow coulters, many of which are still in use." From the same gentleman we learn that old residents of Carroll county have a tradition that iron was once made in that county in hollow stumps of trees, which is not improbable, the iron ore of the county being a soft hematite, which could be easily reduced. Iron ore of the quality

mentioned is very abundant near Berryville. We have no knowledge that any other iron-manufacturing enterprises than those above mentioned have ever existed in this State.

Texas does not appear to have had any iron enterprises of any kind before the civil war, but three small furnaces are reported to have been abandoned at the close of the war. They were probably built during its continuance to meet the necessities of the Confederate Government. In 1869 a charcoal furnace was built at Jefferson, in Marion county, which was rebuilt in 1874. It was in operation in 1880, and was then the only furnace in the State. It was called Kelly furnace, after Mr. G. A. Kelly, the president of the Jefferson Iron Company, by which it was owned. It is still in operation, but is now called the Lou-Ellen furnace, its owner being the Marshall Car and Foundry Company. It uses brown hematite ore found in the neighborhood. The same company is now building another furnace. In 1883 a furnace was built at Rusk, in Cherokee county, and called Alcalde. The first rolling mill in Texas was started at Houston early in 1884. It is owned by the Houston Rolling Mills and Iron Company.

Kansas had two rolling mills in operation in 1880, both of which were built to re-roll rails. One of these, at Rosedale, in Wyandotte county, three miles from Kansas City, is owned by the Kansas Rolling Mill Company. This mill was once in operation at Decatur, Illinois, where it was built in 1870, and whence it was removed to Rosedale in 1875. The other mill was located at Topeka, and was built in 1874 by the Topeka Rolling Mill Company. This mill was burned in April, 1881. The Rosedale mill has not been in operation since 1882.

Nebraska had one iron enterprise in operation in 1880—a rolling mill and cut-nail factory at Omaha, owned by the Omaha Iron and Nail Company. These works were first built at Dunleith, Illinois, in 1875 and 1876, and were removed to Omaha in 1879 and considerably enlarged. They have an annual capacity of 65,000 kegs of nails. They are still in operation, using old iron exclusively.

In 1877 a rolling mill was removed by William Faux from Danville, Pennsylvania, to Pueblo, Colorado, and put in operation on March 1, 1878, its product being re-rolled rails. In

the same year it was removed to Denver. It was in operation in 1883, rolling bar iron as well as re-rolling rails. This mill is now owned by the Colorado Coal and Iron Company. In 1880 this company commenced the erection of a large coke furnace at South Pueblo, Colorado, which was put in blast on September 7, 1881. In the former year it commenced the construction of Bessemer steel works at the same place, which were finished in 1882. These enterprises are part of a very extensive and complete establishment, which now embraces a blast furnace, Bessemer steel works, a rolling mill for rolling steel rails, and a nail mill. The erection of a second blast furnace has been commenced. Extensive coke works have already been built by the company. At El Moro the number of ovens now completed is 250, and at Crested Butte there are 100 ovens. At Gunnison the erection of two furnaces to use coke has been commenced by the Gunnison Coal and Steel Company.

The Union Pacific Railroad Company built a rolling mill to re-roll rails at Laramie City, Wyoming Territory, in 1874, and put it in operation in April, 1875. It was in operation in 1883.

In 1859 Lesley reported a forge in Utah Territory, "smelting iron ore found in the mountains east of Salt Lake City, but no reliable information could be obtained respecting it." It does not appear in the census of 1860. Dr. J. S. Newberry writes that in 1880 he "visited the deposit of crystalline iron ore of Iron county, in the southern part of the Territory. These ore beds have been long known, and were to some extent utilized by the Mormons in their first advent thirty years ago. The iron region referred to lies nearly 300 miles directly south of Salt Lake City." In 1874 the Great Western Iron Company, of which John W. Young was president, built a charcoal furnace at Iron City, in Iron county. It was in blast in that year and in the two following years, but has since been idle. This is a very small furnace, being only nineteen feet high and four feet wide at the boshes, with a daily capacity of five tons. The erection of a much larger furnace, also to use charcoal, was commenced at Ogden City, Utah, in 1875, by the Ogden Iron Manufacturing Company, and was intended to use hematite and magnetic ores found in the neighbor-

hood. The furnace was completed and put in blast in 1883, but was blown out after making a small quantity of pig iron. The same company commenced building a rolling mill at Ogden City in 1875, which was not completed until 1882. It appears to have never been put in operation.

California has for many years had a very complete rolling mill at San Francisco, owned by the Pacific Rolling Mill Company. It was first put in operation on July 25, 1868. It rolls rails, bar iron, angle iron, shafting, etc. It was in operation in 1883, and has always been well employed. The California Iron and Steel Company commenced in 1880 the erection of a charcoal furnace at Clipper Gap, in Placer county, where iron ore had been discovered, and in the same year the Central Pacific Railroad Company commenced the erection at Sacramento City of a small mill to roll bar iron. The Clipper Gap furnace was put in blast in April, 1881, and the first cast was made on the 24th of that month. Since then it has been burned down and rebuilt and again put in operation. In 1883 the Judson Manufacturing Company completed and put in operation a rolling mill at Oakland for the manufacture of bar and plate iron; and in the same year the Pacific Iron and Nail Company completed and put in operation at the same place a large rolling mill and nail factory, with an annual capacity of more than 100,000 kegs of nails. California may have had a forge or two while it was Mexican territory, but it is doubtful whether its Mexican inhabitants ever engaged in the manufacture of iron.

At Oswego, in Clackamas county, Oregon, a furnace to use charcoal was built in 1866 and enlarged in 1879. It was in blast in 1883, when it produced 7,000 net tons of pig iron. Its charcoal is made exclusively from the fir tree.

A furnace at Irondale, near Port Townsend, in Jefferson county, Washington Territory, was built in 1880, and put in blast early in 1881. It is a small furnace, and was built to make charcoal pig iron from Puget sound bog ore mixed with Texada Island magnetic ore. It is owned by the Puget Sound Iron Company, of Port Townsend.

The States and Territories which have not been referred to in these pages are believed to have never been engaged in the manufacture of iron.

CHAPTER XXXIV.

THE FIRST IRON WORKS IN CANADA.

A notice in these pages of the first iron works in Canada will be read with interest, especially as these works are still in operation. They are known as the forges of St. Maurice, and are located near Three Rivers, in the province of Quebec. Mr. A. T. Freed, the editor-in-chief of the Hamilton (Ontario) *Spectator*, informs us that iron ore in the vicinity of Three Rivers was discovered as early as 1666. In 1672 the Count de Frontenac reported that he had begun to mine the ore at Three Rivers. He strongly urged the establishment of forges and a foundry. In 1685 the Marquis de Denouville sent to France a sample of the ore at Three Rivers, which the French iron-workers found to be "of good quality and percentage." But no effort to establish iron works at this place appears to have been made until the next century, when the St. Maurice works were undertaken. Dr. T. Sterry Hunt, of Montreal, has supplied us with the following brief history of these works.

King Louis XIV. gave a royal license in 1730 to a company to work the iron ores of St. Maurice and the vicinity, and advanced 10,000 livres for aid in erecting the furnace, etc. No work being done he took back the license, and in 1735 granted it to a new company, which received 100,000 livres in aid, and in 1737 built a blast furnace. In 1743, however, the works reverted to the crown, and were worked for the king's profit. He then sent out from France skilled workmen, who rebuilt, in part at least, the blast furnace as it now stands, and erected a Walloon hearth, which is still in use, for refining. The works became the property of the British Crown at the conquest, and were at first rented to a company and afterwards sold. Smelting has been carried on at this place without interruption to the present time, the bog ores of the region being exclusively used. Three tons of ore make one ton of iron.

There seems to be no doubt that the stack is the one built in 1737, and it is still in blast. It is 30 feet high, and the internal diameter at the hearth is $2\frac{1}{2}$ feet, at the boshes 7 feet, and at the throat $3\frac{1}{2}$ feet. There are two tuyeres, and the blast is cold, with a pressure of one pound. The daily production of iron is four tons, and the consumption of charcoal is 180 bushels, (French,) of about 12 pounds each, per ton of iron. The metal was formerly used in the district for ordinary castings, but is now in great de-

mand for car-wheels. A very little is, however, refined in the Walloon hearth, and is esteemed by the blacksmiths for local use. The analysis of a sample of the gray pig of St. Maurice made by me in 1868 gave: phosphorus, .450; silicon, .860; manganese, 1.240; graphite, 2.820; carbon combined, 1.100.

In addition to the above information we find some facts of interest concerning the St. Maurice iron works in Peter Kalm's *Travels into North America*, written in 1749.

The iron work, which is the only one in this country, lies three miles to the west of Trois Rivieres. Here are two great forges, besides two lesser ones to each of the great ones, and under the same roof with them. The bellows were made of wood, and everything else as it is in Swedish forges. The melting ovens stand close to the forges, and are the same as ours. The ore is got two French miles and a half from the iron works, and is carried thither on sledges. It is a kind of moor ore, which lies in veins, within six inches or a foot from the surface of the ground. Each vein is from six to eighteen inches deep, and below it is a white sand. The veins are surrounded with this sand on both sides, and covered at the top with a thin mould. The ore is pretty rich and lies in loose lumps in the veins, of the size of two fists, though there are a few which are eighteen inches thick. These lumps are full of holes, which are filled with ochre. The ore is so soft that it may be crushed betwixt the fingers. They make use of a grey limestone, which is broke in the neighborhood, for promoting the fusibility of the ore; to that purpose they likewise employ a clay marble, which is found near this place. Charcoals are to be had in great abundance here, because all the country round this place is covered with woods which have never been stirred. The charcoals from evergreen trees, that is from the fir kind, are best for the forge, but those of deciduous trees are best for the smelting oven. The iron which is here made was to me described as soft, pliable, and tough, and is said to have the quality of not being attacked by rust so easily as other iron; and in this point there appears a great difference between the Spanish iron and this in shipbuilding.

This iron work was first founded in 1737, by private persons, who afterwards ceded it to the king; they cast cannon and mortars here, of different sizes, iron stoves, which are in use all over Canada, kettles, etc., not to mention the bars which are made here. They have likewise tried to make steel here, but can not bring it to any great perfection, because they are unacquainted with the manner of preparing it.

Mr. Freed says that the French company which established the St. Maurice iron works in 1737 was known as *Cugnet et Cie.* He also says that there was a French garrison at Three Rivers at the time, and that the soldiers were the principal workmen. He sends us a copy of a report made in 1752 to M. Bigot, Intendant of New France, residing at Quebec, by M. Franquet, who had been instructed to visit and examine

the St. Maurice works. From this report the following extract is taken:

> On entering the smelting forge I was received with a customary ceremony; the workmen moulded a pig of iron about 15 feet long for my especial benefit. The process is very simple: it is done by plunging a large ladle into the liquid-boiling ore and emptying the material into a gutter made in the sand. After this ceremony I was shown the process of stove moulding, which is also a very simple but rather intricate operation. Each stove is in six pieces, which are separately moulded; they are fitted into each other and form a stove about three feet high. I then visited a shed where the workmen were moulding pots, kettles, and other hollow-ware. On leaving this part of the forge we were taken to the hammer forge, where bar iron of every kind is hammered out. In each department of the forges the workmen observed the old ceremony of brushing a stranger's boots, and in return they expect some money to buy liquor to drink the visitor's health. The establishment is very extensive, employing upward of 180 men. Nothing is consumed in the furnaces but charcoal, which is made in the immediate vicinity of the post. The ore is rich, good, and tolerably clean. Formerly it was found on the spot; now the director has to send some little distance for it. This iron is preferred to the Spanish iron, and is sold off in the king's stores in Quebec.

Still quoting from Mr. Freed we learn that in 1815 a visitor to the St. Maurice works wrote as follows: "The foundry itself is replete with convenience for carrying on an extensive concern; furnaces, forges, casting-houses, workshops, etc. The articles manufactured consist of stoves of all descriptions that are used throughout the provinces, large caldrons or kettles that are used for making potashes, machinery for mills, with cast or wrought-iron work of all denominations. There are likewise large quantities of pig and bar iron exported. The number of men employed is from 250 to 300." The works remained in the ownership of the British Government until 1846, when they were sold to Henry Stuart. A report to the Dominion Parliament in 1879 says that they were then owned by F. Macdougall & Son, of Three Rivers, and were using bog ore and making good iron with charcoal. "The first furnace was erected in 1737; still running; capacity four tons." *This is the oldest active furnace on the American continent.* Canada has had but few other iron enterprises.

It would not be profitable to give such fragmentary information as is at our command concerning the very small iron industry of Mexico and South America.

CHAPTER XXXV.

THE MANUFACTURE OF IRON IN THE UNITED STATES WITH ANTHRACITE COAL.

THE details which have been given in preceding chapters of the early iron history of the Atlantic States of the Union relate almost entirely to the manufacture of charcoal iron, no other fuel than charcoal having been used in American blast furnaces until about 1840. The period of our iron history prior to 1840 may therefore very properly be styled the charcoal era. The later development of the iron and steel industries of the Atlantic States and of other States which have a more modern iron history will be generally instead of provincially treated in the present and in succeeding chapters.

The line which separates the charcoal era of our iron history from the era which succeeded it, and which may be said to still continue, is marked by the introduction of anthracite and bituminous coal in the manufacture of pig iron. This innovation at once caused a revolution in the whole iron industry of the country. Facilities for the manufacture of iron were increased; districts which had been partly closed to this industry because of a scarcity of timber for the supply of charcoal were now fully opened to it; and the cheapening of prices, which was made possible by the increased production and the increased competition, served to stimulate consumption. A notable result of the introduction of mineral fuel was that, while it restricted the production of charcoal pig iron in the States which, like Pennsylvania, possessed the new fuel, it did not injuriously affect the production of charcoal pig iron in other States. Some of these States, notably Michigan, which scarcely possessed an iron industry of any kind in 1840, now manufacture large quantities of charcoal pig iron. The country at large now annually makes more charcoal pig iron than it did in 1840 or in any preceding year. The introduction of mineral fuel did not, therefore, destroy our charcoal-iron industry, but simply added to our resources for the production of iron. This introduction, however, marked such

radical changes in our iron industry, and so enlarged the theatre of this industry, that we are amply justified in referring to it as a revolution, and as one which ended the distinctive charcoal era.

Of the two forms of mineral fuel—anthracite and bituminous coal—anthracite was the first to be largely used in American blast furnaces, and for many years after its adaptability to the smelting of iron ore was established it was in greater demand for this purpose than bituminous coal. In recent years the relative popularity of these two fuels for blast furnace use has been reversed.

The natural difficulties in the way of the successful introduction of anthracite coal in our blast furnaces were increased by the fact that, up to the time when we commenced our experiments in its use, no other country had succeeded in using it as a furnace fuel. The successive steps by which we were enabled to add the manufacture of anthracite pig iron to that of charcoal pig iron will be presented in chronological order.

In 1840 Jesse B. Quinby testified, in the suit of Farr & Kunzi against the Schuylkill Navigation Company, that in 1815 he used anthracite coal for a short time at Harford furnace, in Maryland, mixed with one-half charcoal. Between 1824 and 1828 Peter Ritner, whose brother, Joseph Ritner, afterwards became Governor of Pennsylvania, was successful for a short time in using anthracite coal mixed with charcoal in a charcoal furnace in Perry county, Pennsylvania. In 1826 the Lehigh Coal and Navigation Company erected at Mauch Chunk, in Pennsylvania, a small furnace intended to use anthracite coal in smelting iron ore. The enterprise was not successful. In 1827 unsuccessful experiments in smelting iron ore with anthracite coal from Rhode Island were made at one of the small blast furnaces at Kingston, in Plymouth county, Massachusetts. In 1827 and 1828 a similar failure in the use of anthracite coal took place at Vizille, in France. These last-mentioned experiments failed because the blast used was cold. The hot-blast had not then been invented.

In 1828 James B. Neilson, of Scotland, obtained a patent for the use of hot air in the smelting of iron ore in blast furnaces, and in 1829 pig iron was made in several Scotch fur-

naces with the apparatus which he had invented. But the coal used was bituminous. It was not until 1836 that the smelting of iron ore with anthracite coal by means of the hot-blast invented by Neilson was undertaken in Great Britain. In the mean time the application of the hot-blast to anthracite coal in American furnaces was successfully experimented upon by an enterprising German-American, the Rev. Dr. Frederick W. Geissenhainer, a Lutheran clergyman of New York City. A copy in his own handwriting of a letter written by him in November, 1837, to the commissioner of patents, gives some interesting and valuable details concerning his experiments. In this letter, which we have before us, he says: "I can prove that, in the month of December, 1830, and in the months of January, February, and March, 1831, I had already invented and made many successful experiments as well with *hot air* as with an atmospheric air blast to smelt iron ore with *anthracite coal* in my small experimenting furnace here in the city of New York."

On the 5th of September, 1831, Dr. Geissenhainer filed in the patent office at Washington an account of his invention, for which he claimed a patent. On the 19th of December, 1833, a patent was granted to him for "a new and useful improvement in the manufacture of iron and steel by the application of anthracite coal." From the long and remarkably clear and learned specification by the Doctor, which accompanied the patent, we learn that he discovered that iron ore could be smelted with anthracite coal by applying "a blast, or a column, or a stream, or current of air in or of such quantity, velocity, and density or compression as the compactness or density and the continuity of the anthracite coal requires. The blast may be of common atmospheric *or of heated air. Heated air* I should *prefer* in an economical point of view."

The Doctor distinctly disclaims in his specification "an exclusive right of the use of heated air for any kind of fuel," from which it is to be inferred that he had full knowledge of Neilson's experiments with hot air in Scotland. He appears to have relied for success largely upon the effect of a strong blast.

The patent having been granted, Dr. Geissenhainer pro-

ceeded to build a furnace for the practical application of his invention. This was Valley furnace, situated on Silver creek, in Schuylkill county, Pennsylvania, about ten miles northeast of Pottsville. In August and September, 1836, he was successful in making pig iron at this furnace exclusively with anthracite coal as fuel. His own testimony on this point is given in the letter from which we have already quoted. The blast used varied from $3\frac{1}{2}$ to $3\frac{1}{4}$, to 3, and to $2\frac{3}{4}$ pounds to the square inch. That the furnace did not continue to make iron after the autumn of 1836 is explained by Dr. Geissenhainer to have been due to an accident to its machinery. He adds: "My furnace would have been put in operation again long before this time with strong iron machinery, and *a hot-air apparatus,* had I not been prevented by the pressure of the times and by a protracted severe sickness from bestowing my attention to this matter. The drawings for the iron machinery and for the hot-air apparatus are already in the hands of Messrs. Haywood & Snyder, in Pottsville, who are to do the work." The blast used in August and September, 1836, was heated.

Before the Doctor's plans for improving his furnace were completed he was called to another world. He died at New York on the 27th of May, 1838, aged 66 years and 11 months. He was born at Muhlberg, in the Electorate of Saxony, in 1771, and came to this country when about 18 years old. His remains rest in the family burial vault in the Lutheran cemetery in Queens county, New York.

Prior to the erection of Valley furnace Dr. Geissenhainer had been engaged in the development of the iron and coal resources of Pennsylvania. As early as 1811 he was associated with Peter Karthaus, of Baltimore, in the mining of bituminous coal in Clearfield county, and a few years later in the ownership of a charcoal furnace in that county. For two or three years prior to 1830 he owned and operated a small charcoal furnace in Schuylkill county, and it was near this furnace that he afterwards built Valley furnace. Attached to the charcoal furnace was a puddling furnace. He was the pioneer in the development of the Silver creek anthracite coal mines, the projector of the Schuylkill Valley Railroad, and the sole owner of the Silver Creek Railroad. Dr. Geissen-

hainer was, as will be seen, a man of great enterprise. His memory as the first successful manufacturer of pig iron with anthracite coal and the hot-blast is entitled to greater honor than it has yet received.

On the 28th of September, 1836, when Dr. Geissenhainer's Valley furnace was successfully making pig iron, and almost three years after the Doctor had obtained a patent for his invention, George Crane, the owner of several furnaces at Yniscedwin, in South Wales, obtained a patent from the British Government for the application of the hot-blast to the smelting of iron ore with anthracite coal. On the 7th of February, 1837, he successfully commenced the use of anthracite with the hot-blast at one of his furnaces, obtaining 36 tons a week. In May of that year Solomon W. Roberts, of Philadelphia, visited his works and witnessed the complete success of the experiment, which was the first successful experiment with anthracite coal in a blast furnace in Europe. It was through Mr. Roberts's representations to his uncle, Josiah White, and to Erskine Hazard and others that the first anthracite furnace in the Lehigh valley was built at Catasauqua in 1839 and 1840 by the Lehigh Crane Iron Company.

Solomon White Roberts was born in Philadelphia on August 3, 1811, and died in the same city on March 22, 1882. He is buried at Woodlands cemetery.

Mr. Crane endeavored to obtain a patent in this country for his application of the hot-blast to anthracite coal in the blast furnace, but was unsuccessful, Dr. Geissenhainer's patent covering the same principle. The Doctor's patent, which was only for the United States, was sold by his executors in 1838 to Mr. Crane, who, in November of that year, patented in this country some additions to it. The patents could not be enforced here, but Mr. Crane compelled the ironmasters of Great Britain to pay him for the use of his invention. Dr. Geissenhainer never attempted to enforce his patent. The consideration which his executors received from Mr. Crane was $1,000 and the privilege of erecting, free of royalty, fifteen furnaces for the use of anthracite coal with the hot-blast. The following advertisement by Mr. Crane's agents in this country we take from a Philadelphia newspaper published in December, 1839, just forty-five years ago.

ANTHRACITE IRON.—The subscribers, agents of George Crane, Esq., are prepared to grant licenses for the manufacture of iron with anthracite coal, under the patent granted to Mr. Crane by the United States, for smelting iron with the above fuel, in addition to which Mr. Crane holds an assignment of so much of the patent granted to the late Reverend Dr. Geissenhainer as pertains to making iron with anthracite coal. The charge will be 25 cents per ton on all thus manufactured. It has been completely successful both in Wales and at Pottsville, one furnace at the latter place yielding an average product of 40 tons per week of excellent iron. All persons are cautioned against infringing upon either of the above patents. Any application of hot-blast in the smelting of iron ore with anthracite coal, without a license, will be an infringement, and will be treated accordingly.

Apply to A. & G. RALSTON & CO.,
dec 9—1m 4 South Front st.

George Crane was born about 1784 at Bromsgrove, in Worcestershire, England, whence he removed in 1824 to Wales. He died on the 10th of January, 1846, in the 62d year of his age. An obituary notice of Mr. Crane, written by Solomon W. Roberts, is printed in the *Journal of the Franklin Institute* for March, 1846.

Two interesting experiments in the use of anthracite coal in the blast furnace were made in this country about the time when Dr. Geissenhainer succeeded with his experiment at Valley furnace. In 1836 and 1837 John Pott experimented at Manheim furnace, at Cressona, in Schuylkill county, with anthracite coal as a fuel for smelting iron ore. He first used a mixture of anthracite coal and charcoal with cold-blast. The results accomplished were so encouraging that he added a hot-blast and gradually reduced the proportion of charcoal until only anthracite was used. This he used alone and successfully for a short time. But the blast was too weak, and the furnace was not long in operation. Before the necessary improvements could be made it was destroyed by a freshet. In 1837 Jarvis Van Buren, acting for a company, built a furnace at South Easton, in Northampton county, for the purpose of experimenting with anthracite coal. Early in 1838 he was successful in making 20 tons of pig iron, when further operations were stopped in consequence of the blast being too weak. We are not informed whether it was hot or cold.

It is claimed that a successful experiment in the manufacture of pig iron with anthracite coal was made in 1837 by a Mr. Bryant, in a foundry cupola at Manayunk, near Philadel-

phia. The blast used was produced by "wooden bellows." A few tons of the iron made were used by Parke & Tiers, the owners of the foundry, "and proved to be of good gray quality and of uncommon strength." The experiment was conducted under the auspices of this firm and of Mr. Abraham Kunzi, of the firm of Farr & Kunzi, manufacturing chemists, of Philadelphia. The blast was cold.

The record which we shall now give of the successful use of anthracite coal in American furnaces, after Dr. Geissenhainer and George Crane had established the practicability of such use, will embrace only a few of the early anthracite furnaces, and this we condense from Walter R. Johnson's *Notes on the Use of Anthracite*, published in 1841, and from William Firmstone's "Sketch of Early Anthracite Furnaces," published in the third volume of the *Transactions of the American Institute of Mining Engineers.* In each of the instances to be referred to the blast used was heated.

Late in 1837 Joseph Baughman, Julius Guiteau, and Henry High, of Reading, experimented in smelting iron ore with anthracite coal in the old furnace of the Lehigh Coal and Navigation Company at Mauch Chunk, using about 80 per cent. of anthracite. The results were so encouraging that they built a small water-power furnace near the Mauch Chunk weigh-lock, which was completed in July, 1838. Blast was applied to this furnace on August 27th, and discontinued on September 10th, the temperature being heated up to about 200° Fahrenheit. The fuel used was mainly but not entirely anthracite. A new heating apparatus was procured, placed in a brick chamber at the tunnel-head, and heated by a flame therefrom. Blast was applied late in November, 1838, the fuel used being anthracite exclusively, and "the furnace worked remarkably well for five weeks," up to January 12, 1839, when it was blown out for want of ore. Some improvements were made, and on July 26, 1839, the furnace was again put in blast, and so continued until November 2, 1839. Mr. F. C. Lowthorp, of Trenton, was one of the partners at this time. For "about three months" no other fuel than anthracite was used, the temperature of the blast being from 400° to 600°. About 100 tons of iron were made.

The next furnace to use anthracite was the Pioneer, built

in 1837 and 1838 at Pottsville, by William Lyman, of Boston, under the auspices of Burd Patterson. Blast was unsuccessfully applied on July 10, 1839. Benjamin Perry then took charge of it, and blew it in on October 19, 1839, with complete success. This furnace was blown by steam-power. The blast was heated with anthracite, in ovens at the base of the furnace, to a temperature of 600°. The product was about 28 tons a week of good foundry iron. The furnace continued in blast for some time. A premium of $5,000 was paid by Nicholas Biddle and others to Mr. Lyman, as the first person in the United States who had made anthracite pig iron continuously for three months. On the 18th of January, 1840, a dinner was given to Mr. Lyman in honor of the important event, at which a notable address was delivered by Mr. Biddle. Pioneer furnace was torn down and rebuilt in 1853.

Danville furnace, in Montour county, was successfully blown in with anthracite in April, 1840, producing 35 tons of iron weekly with steam-power. Roaring Creek furnace, in Montour county, was next blown in with anthracite on May 18, 1840, and produced 40 tons of iron weekly with water-power.

A charcoal furnace at Phœnixville, built in 1837 by Reeves, Buck & Co., was blown in with anthracite on June 17, 1840, by William Firmstone, and produced from 28 to 30 tons of pig iron weekly with water-power. The hot-blast stove, which was planned and erected by Julius Guiteau, of the Mauch Chunk furnace, was situated on one side of the tunnel-head, and heated by the flame of the furnace. This furnace continued in blast until 1841.

Columbia furnace, at Danville, was blown in with anthracite by Mr. Perry on July 2, 1840, and made from 30 to 32 tons of iron weekly, using steam-power.

The next furnace to use anthracite, and the last one we shall mention, was built at Catasauqua, for the Lehigh Crane Iron Company, in 1839, by David Thomas, who had been associated with Mr. Crane in his experiments at Yniscedwin. It was successfully blown in by him on the 3d of July, 1840, and its first cast was made on July 4th. From the first this furnace produced 50 tons a week of good foundry iron, water-power being used. The furnace was in active use until 1879,

when it was torn down. Mr. Firmstone says that "with the erection of this furnace commenced the era of higher and larger furnaces and better blast machinery, with consequent improvements in yield and quality of iron produced."

In the memoir of Josiah White, by his son-in-law, Richard Richardson, we find the following statement: "In 1838 Erskine Hazard went to Wales, and there made himself acquainted with the process and manner of making the anthracite iron, with the machinery and buildings needful for its manufacture. He ordered such machinery as was necessary to be made for the company, under the direction of George Crane, the inventor, and engaged David Thomas, who was familiar with the process, to take charge of the erection of the works and the manufacture of the iron. He arrived in the summer of 1839, and to his faithful and intelligent management much of the success of the enterprise is due."

David Thomas was born on November 3, 1794, at a place called, in English, Grey House, within two and a half miles of the town of Neath, in the county of Glamorgan, South Wales. He landed in the United States on June 5, 1839, and on July 9th of that year he commenced to build the furnace at Catasauqua. He died at Catasauqua on June 20, 1882, in his 88th year. At the time of his death he was the oldest ironmaster in the United States in length of service, and next to Peter Cooper he was the oldest in years. David Thomas's character and services to the American iron trade are held in high honor by all American iron and steel manufacturers. He is affectionately styled the Father of the American anthracite iron industry, because the furnace built under his directions at Catasauqua and blown in by him was the most successful of all the early anthracite furnaces, and also because he subsequently became identified with the manufacture of anthracite pig iron on a more extensive scale than any of his cotemporaries. An obituary notice of Mr. Thomas will be found in *The Bulletin of The American Iron and Steel Association* for June 28, 1882. William Cullen Bryant and David Thomas were born on the same day.

In 1835 the Franklin Institute, of Philadelphia, offered a premium of a gold medal "to the person who shall manufacture in the United States the greatest quantity of iron from

the ore during the year, using no other fuel than anthracite coal, the quantity to be not less than twenty tons," but we can not learn that the medal was ever awarded to any of the persons who were instrumental in establishing the manufacture of anthracite pig iron in this country. The offer of the medal proves that down to 1835 all efforts to manufacture pig iron with anthracite coal had been unsuccessful.

The discovery that anthracite coal could be successfully used in the manufacture of pig iron gave a fresh impetus to the iron industry in New York, New Jersey, and Maryland, as well as in Pennsylvania. In 1840 there were only six furnaces in the United States which used anthracite coal, and they were all in Pennsylvania. The first anthracite furnace outside of Pennsylvania was built at Stanhope, New Jersey, in 1840 and 1841, by the Stanhope Iron Company, and it was successfully blown in on April 5, 1841. On the 1st of April, 1846, there were forty-two furnaces in Pennsylvania and New Jersey which used anthracite coal as fuel, their annual capacity being 122,720 tons. In 1856 there were 121 anthracite furnaces in the country which were either "running or in running order"—ninety-three in Pennsylvania, fourteen in New York, six in Maryland, four in New Jersey, three in Massachusetts, and one in Connecticut. Soon after 1856 many other furnaces were built to use anthracite as fuel.

Although the revolution to which we have referred properly dates from the first successful use of anthracite coal in the blast furnace, this fuel had previously been used in a small way in this country in other iron-making operations. Its use in these operations became general about the time when pig iron was first made with it.

To encourage the use of anthracite coal the Lehigh Coal-Mine Company executed, on the 18th of December, 1807, a lease for twenty-one years to James Butland and James Rowland of two hundred acres of its land in Northampton county, Pennsylvania, with the privilege of digging iron ore and coal free for the manufacture of iron. The enterprise was unfruitful, and the lease was abandoned about 1814. No iron was made, and we think that no coal was mined. The following extract from the proposition of Butland & Rowland, dated November 30, 1807, is worthy of preservation: "The subscrib-

ers, having obtained by patent from the United States an exclusive right of using a natural carbon or peculiar kind of coal, such as is found in the neighborhood of the Lehigh and Susquehanna rivers, and other parts of the United States, for the purpose of manufacturing pig, cast, and bar iron, propose commencing the operation in such a situation as may be deemed best adapted to the purpose."

The first use of anthracite coal in connection with the manufacture of iron in the United States dates from 1812, in which year Colonel George Shoemaker, of Pottsville, Pennsylvania, loaded nine wagons with coal from his mines at Centreville, and hauled it to Philadelphia, where with great difficulty he sold two loads at the cost of transportation and gave the other seven loads away. He was by many regarded as an impostor for attempting to sell stone to the public as coal. Of the two loads sold, one was purchased by White & Hazard, for use at their wire works at the Falls of Schuylkill, and the other was purchased by Malin & Bishop, for use at the Delaware County rolling mill. By the merest accident of closing the furnace doors Mr. White obtained a hot fire from the coal, and from this occurrence, happening in 1812, we may date the first successful use of anthracite coal in the manufacture of iron in this country and in other American manufactures. At both the establishments mentioned it was used in the heating furnaces. Previous to this time bituminous coal from Virginia and Great Britain had been relied upon for manufacturing purposes in the Atlantic States in all cases where wood was not used. The firm of White & Hazard was composed of Josiah White and Erskine Hazard.

In the latter part of 1823 the Boston Iron Company, owning the Boston iron works, obtained a full cargo of Lehigh anthracite coal, for use in heating iron to be rolled in its mill, and for smith-work. A short time previous to this transaction, but in the same year, Cyrus Alger, of South Boston, obtained a lot of about thirty tons of Lehigh coal, which he used in a cupola for melting iron for castings.

Anthracite coal for the generation of steam was first used in this country in January, 1825, under the boilers of the rolling mill at Phœnixville, of which Jonah and George Thompson, of Philadelphia, were the proprietors. It is also claimed

that, two years later, in 1827, the first use of anthracite coal in the puddling furnace in this country was at the same rolling mill, Jonah and George Thompson still being the proprietors. The use of anthracite for puddling did not become general until about 1840. In 1839 anthracite coal was used in puddling at the Boston iron works by Ralph Crooker, the superintendent. About 1836 Thomas and Peter Cooper, brothers, used anthracite in a heating furnace at their rolling mill on Thirty-third street, near Third avenue, New York, and about 1840 they began puddling with anthracite. In April, 1846, there were twenty-seven rolling mills in Pennsylvania and New Jersey that were using anthracite coal.

The following notice of the success of the Messrs. Thompson in the use of anthracite coal for the production of steam appeared in 1825 in a newspaper published at West Chester, Pennsylvania. "We understand that the Messrs. Thompson, at the Phœnix nail works, on French creek, have fully succeeded in constructing a furnace for a steam engine calculated for the use of anthracite coal, and in discovering a mode by which this fuel may be most advantageously applied to that important purpose. We would heartily congratulate the eastern section of our State upon this valuable discovery. Nothing within our knowledge has occurred of recent date which can have a more auspicious influence upon our manufacturing interests."

We may properly close this chapter and introduce its successor by quoting the following extract from the letter of instructions by the Acting Committee of The Pennsylvania Society for the Promotion of Internal Improvement to its European agent, William Strickland. This letter is dated at Philadelphia, March 18, 1825. In speaking of the manufacture of iron in Pennsylvania, and the necessity of enlarging it by the adoption of European methods, the committee says:

> No improvements have been made here in it within the last thirty years, and *the use of bituminous and anthracite coal in our furnaces is absolutely and entirely unknown.* Attempts, and of the most costly kind, have been made to use the coal of the western part of our State in the production of iron. Furnaces have been constructed according to the plan *said* to be adopted in Wales and elsewhere; persons claiming experience in the business have been employed; but all has been unsuccessful.

CHAPTER XXXVI.

THE MANUFACTURE OF IRON IN THE UNITED STATES WITH BITUMINOUS COAL.

It is remarkable that the introduction of bituminous coal in the blast furnaces of this country should have taken place at so late a day in our history, and within the memory of men who are not yet old. Bituminous coal had been discovered in the United States long before any attempt was made to use it in our blast furnaces, and Great Britain had taught us while we were still her colonies that it could be so used. In 1735 Abraham Darby, at his furnace at Coalbrookdale, in Shropshire, had successfully made pig iron with coke as fuel; in 1740 a coke furnace was built at Pontypool, in Monmouthshire; and in 1796 charcoal furnaces had been almost entirely abandoned in Great Britain. Our delay in following the example of the mother country may be variously explained. There was a lack of transportation facilities for bringing iron ore and coke together; not all of the bituminous coal that had been discovered was suitable for making good coke; the manufacture of coke was not well understood; the country had an abundance of timber for the supply of charcoal; and, finally, a prejudice existed in favor of charcoal pig iron and of bar iron hammered in charcoal forges. It was not until about 1840 that successful efforts were made to introduce the use of bituminous coal in American blast furnaces.

The successful introduction of bituminous coal as a fuel in American blast furnaces was naturally preceded by many experiments in its use, which were attended with varied success, but none of them with complete success. It appears to be mathematically certain that down to 1835 all of these experiments had been unsuccessful, as in that year the Franklin Institute, of Philadelphia, offered a premium of a gold medal "to the person who shall manufacture in the United States the greatest quantity of iron from the ore during the year, using no other fuel than bituminous coal or coke, the quantity to be not less than twenty tons." The Institute would

not have been likely to make this offer if even so small a quantity as twenty tons of pig iron had been made in one furnace with bituminous coal, either coked or uncoked.

The earliest experiment in the United States in the manufacture of pig iron with bituminous coal that appears to be fully authenticated was made at Bear Creek furnace, in Armstrong county, Pennsylvania, in 1819. This furnace was built to use coke, with steam-power, and in the year named it was blown in with this fuel, but the blast was cold and too weak, and the furnace chilled after two or three tons of iron had been made. Charcoal was then substituted.

In a report by a committee of the Senate of Pennsylvania, of which Hon. S. J. Packer was chairman, read in the Senate on March 4, 1834, it was stated that "the coking process is now understood, and our bituminous coal is quite as susceptible of this operation, and produces as good coke, as that of Great Britain. It is now used to a considerable extent by our iron manufacturers in Centre county and elsewhere." It is certain that, at the time this report was written, coke could not have been used in blast furnaces in any other way than as a mixture with charcoal, and then only experimentally. Mr. Packer doubtless had in mind the use of coke in melting pig iron in "run-out" or "finery" fires preparatory to converting it into blooms or bars in charcoal forges.

The offer of the gold medal by the Franklin Institute doubtless assisted in stimulating action upon a subject which had already attracted much attention. In the year in which this offer was made, 1835, that accomplished furnace manager, William Firmstone, was successful in making good gray forge iron for about one month at the end of a blast at Mary Ann furnace, in Huntingdon county, Pennsylvania, with coke made from Broad Top coal. This iron was taken to a forge three miles distant and made into blooms. The coke used at the furnace was not prepared to be so used, but had been made for use in the "run-out" fires at the forge connected with the furnace. Mr. Firmstone did not claim the medal. He may not have known that a premium had been offered for the achievement which he undoubtedly accomplished.

In a pamphlet published in April, 1836, Isaac Fisher, of Lewistown, Pennsylvania, stated that "successful experiments

have lately been tried in Pennsylvania in making pig iron with coke." It is probable that Mr. Fisher had in mind Mr. Firmstone's experiment.

William Firmstone was born at Wellington, in Shropshire, England, on October 19, 1810. When quite a young man he was manager at the Lays Works, near Dudley, which were then owned by his uncles, W. & G. Firmstone. He emigrated to the United States in the spring of 1835. After filling many responsible positions in connection with the manufacture of pig iron he died at his residence near Easton, Pennsylvania, on September 11, 1877, and is buried at that place. He was one of the first to introduce the hot-blast in the United States, having successfully added this improvement to Vesuvius furnace, in Lawrence county, Ohio, in 1836. In 1839 he added a hot-blast to Karthaus furnace, in Pennsylvania.

About 1837 F. H. Oliphant, a skillful ironmaster, made at his furnace called Fairchance, near Uniontown, in Fayette county, Pennsylvania, a quantity of coke pig iron in excess of twenty tons, and probably in excess of 100 tons. He did not, however, long continue to make coke iron, and resumed the manufacture of iron with charcoal. Mr. Oliphant had heard of the offer of the gold medal, and in a letter to the Institute, dated October 3, 1837, he modestly referred to his success in making pig iron with coke, and suggested that possibly he was entitled to the premium. Accompanying his letter was a box of pig iron and the raw materials of its manufacture. We do not learn that he ever received the medal, or that anybody received it.

Between 1836 and 1839 other attempts were made at several furnaces in Pennsylvania to use coke, but the experiments were unsuccessful or unfortunate. The legislature of Pennsylvania passed an act on June 16, 1836, "to encourage the manufacture of iron with coke or mineral coal," which authorized the organization of companies for the manufacture, transportation, and sale of iron made with coke or coal. At Farrandsville, in Clinton county, six miles north of Lock Haven, half a million dollars was sunk by a Boston company in a disastrous attempt to smelt the neighboring ores with coke, and to establish other iron and mining enterprises. This company had commenced operations in the mining of coal

as early as 1833. The furnace was blown in in the summer of 1837, and ran probably until 1839. About 3,500 tons of iron were made, but at such great cost, owing to the impurity of the coal and the distance from the ore, that further efforts to make iron with coke were abandoned. At Karthaus, in Clearfield county, the Clearfield Coal and Iron Company, composed of Henry C. Carey, Burd Patterson, John White, and others, succeeded in 1839, under the management of William Firmstone, in making pig iron with coke in a furnace which was built in 1836 by Peter Ritner (brother of Governor Ritner) and John Say, but at the close of the year the whole enterprise was abandoned, owing to the lack of proper transportation facilities. A furnace at Frozen run, in Lycoming county, made some pig iron with coke in 1838, but in 1839 it was using charcoal. The furnaces at Farrandsville and Karthaus were both supplied with hot-blasts—the former in 1837 and the latter in 1839. The apparatus for that at Farrandsville was made at Glasgow, and was the best then known.

It is not generally known that Henry C. Carey, the foremost of American political economists, was ever interested pecuniarily in the manufacture of iron, as we have shown above.

Henry Charles Carey, the distinguished political economist, and son of Mathew Carey, who was also similarly distinguished, was born in Philadelphia on the 15th of December, 1793, and died in the same city on the 13th of October, 1879, having nearly completed his 86th year. He was buried at Burlington, New Jersey, where his wife had previously been buried.

The first notable success in the use of bituminous coal in the blast furnace in this country was achieved at three furnaces in Western Maryland. Lonaconing furnace, in the Frostburg coal basin, on George's creek, eight miles northwest of Frostburg, in Alleghany county, was built in 1837 by the George's Creek Company, to use coke, and in June, 1839, it was making about seventy tons per week of good foundry iron. Alexander says that "the air was heated by stoves placed near the tuyere arches, and attained a temperature of 700 degrees Fahrenheit." The furnace was blown by an engine of 60-horse power. In the same coal basin, on the south branch of Jenning's run, nine miles northwest of Cumberland, two

large blast furnaces were built in 1840 by the Mount Savage Company to use the same fuel. These furnaces were for several years successfully operated with coke. It is worthy of notice that Alexander's report to the Governor of Maryland, made in 1840, and which was the first able and comprehensive contribution to the technical literature of the iron and steel industries of this country, was written partly to show to the people of Maryland the feasibility of substituting coke for charcoal in the manufacture of pig iron, the British blast-furnace practice at that time being largely drawn upon for illustrations of what had already been accomplished in Great Britain with the new fuel.

But the use of coke did not come rapidly into favor, and many experiments with it were attended with loss. It was not until after 1850 that its use began to exert an appreciable influence upon the manufacture of pig iron. In 1849 there was not one coke furnace in blast in Pennsylvania. Thus far coke had not noticeably contributed to the revolution to which we have referred in the preceding chapter. But in 1856 there were twenty-one furnaces in Pennsylvania and three in Maryland that were using coke or were adapted to its use. After 1856 the use of this fuel in the blast furnace increased in Pennsylvania and was extended to other States, but it was not until after 1865 that its use for this purpose increased rapidly. Not more than 100,000 tons of coke were consumed in the production of pig iron in this country in that year. A tremendous stride was taken in the next fifteen years, however, the quantity of coke consumed in the blast furnaces of the United States in the census year 1880 having been 2,128,255 net tons.

While the effort was being made in a few localities in Pennsylvania and Maryland to introduce the use of coke in the blast furnace, attention was also directed to the possibility of using uncoked coal for the same purpose. Alexander says that the proprietors of Lonaconing furnace, in Western Maryland, used raw coal before 1840. He leaves the reader to infer that it was successfully used, but he probably wrote from imperfect information. Some unsuccessful experiments were made with raw coal in Clarion county, Pennsylvania, about 1840. In the sketch of Mercer county, Pennsylvania, in Day's *Historical Collections*, printed in 1843, it is stated that, "in the

vicinity of Sharon, on the Pittsburgh and Erie canal, exists a most valuable bed of coal of peculiar quality, between anthracite and bituminous, without the least sulphur. It has been tried successfully for smelting iron in a common charcoal furnace." It is not certain that the furnace referred to was in Mercer county. The coal mentioned is now classed among bituminous varieties. At Arcole furnace, in Lake county, Ohio, operated by Wilkeson & Co., raw coal from Greenville, Mercer county, Pennsylvania, was experimented with about 1840. John Wilkeson, one of the owners of the furnace at that time, writes us that the experiment "met with a small measure of success." Doubtless the several experiments mentioned were not the only ones that were made with raw coal before success in its use was fully achieved; and doubtless, too, none of the experiments mentioned produced any more satisfactory results than the qualified success attained at Arcole furnace.

The first truly successful use of raw bituminous coal in the blast furnace occurred in the autumn of 1845. It is circumstantially described in the following extract from a pamphlet entitled *Youngstown, Past and Present*, published in 1875. "In July, 1845, Himrod & Vincent, of Mercer county, Pennsylvania, blew in the Clay furnace, not many miles from the Ohio line, on the waters of the Shenango. About three months afterwards, in consequence of a short supply of charcoal, as stated by Mr. Davis, their founder, a portion of coke was used to charge the furnace. Their coal belongs to seam No. 1, the seam which is now used at Sharon and Youngstown, in its raw state, variously known as 'free-burning splint,' or 'block coal,' and which never makes solid coke. A difficulty soon occurred with the cokers, and, as Mr. Himrod states, he conceived the plan of trying his coal without coking. The furnace continued to work well, and to produce a fair quality of metal. It is admitted that Mr. David Himrod, late of Youngstown, produced the first metal with raw coal, about the close of the year 1845." The furnace here alluded to was situated on Anderson's run, in Mercer county, Pennsylvania, about two and one-half miles southeast of Clarksville, and was built in 1845. It has been abandoned for many years. In the chapter relating to Michigan we have mentioned the part

taken by this furnace at an early day in smelting Lake Superior ores with the block coal of the Shenango valley.

In 1845 Messrs. Wilkeson, Wilkes & Co., of Lowell, in Poland township, Mahoning county, Ohio, commenced the erection of Mahoning furnace, as related in the chapter devoted to Ohio, expressly to use coal from their mine near Lowell in its raw state. The furnace was successfully blown in with this fuel by John Crowther on the 8th of August, 1846. It was while this furnace was in course of erection that the use of raw coal at Clay furnace was commenced. It may be added that Mr. Davis, the founder of Clay furnace, visited and inspected Mahoning furnace while work upon it was progressing, and that he had been an employé of the owners of Arcole furnace and was familiar with the experiments that had been made at it in the use of raw coal about 1840. The *Trumbull Democrat*, of Warren, Ohio, for August 15, 1846, in an account of the blowing in of Mahoning furnace, states that "to these gentlemen (Wilkeson, Wilkes & Co.) belongs the honor of being the first persons in the United States who have succeeded in putting a furnace in blast with raw bituminous coal."

John Crowther was an Englishman, born at Broseley, in Shropshire, on May 7, 1797. He emigrated to the United States in 1844, immediately prior to which time he had been the manager of seven blast furnaces in Staffordshire—five at Stowheath and two at Osier Bed. Prior to his connection with the Lowell furnace he had been employed as manager of the furnaces at Brady's Bend. He adapted many furnaces in the Mahoning and Shenango valleys to the use of block coal, and instructed three of his sons in their management, namely, Joshua, Joseph J., and Benjamin. He died on April 15, 1861, at Longton, in Staffordshire, England, where he is buried. Joshua Crowther died in this country in October, 1883, aged over 60 years.

After it had been demonstrated at Clay and Mahoning furnaces that the block coal of the Shenango and Mahoning valleys could be used in the manufacture of pig iron, other furnaces in these two valleys were built to use this fuel, and some charcoal furnaces were altered to use it. In 1850 there were, however, only four furnaces in the Mahoning valley

and only seven in the Shenango valley which used raw coal. After 1850, and especially after the introduction into these valleys of Lake Superior ores, about 1856, the use of raw coal greatly increased. In 1856 six furnaces in Pennsylvania and thirteen in Ohio were using this fuel. Some progress was afterwards made in its use in other States, particularly in Indiana, but down to 1884 its use has been mainly confined to the two valleys mentioned.

The American Iron and Steel Association has published a table which exhibits the production of pig iron in this country in each year from 1854 to 1883, classified according to the fuel used. This table is here reproduced. It shows the growth of the manufacture of pig iron with anthracite and bituminous coal since 1854, and also the periods at which the use of anthracite coal and bituminous coal respectively overtook that of charcoal in the blast furnace. Tons of 2,000 pounds are used.

Years.	Anthracite.	Charcoal.	Bituminous coal and coke.	Total.
	Net tons.	*Net tons.*	*Net tons.*	*Net tons.*
1854	339,435	342,298	54,485	736,218
1855	381,866	339,922	62,390	784,178
1856	443,113	370,470	69,554	883,137
1857	390,385	330,321	77,451	798,157
1858	361,430	285,313	58,351	705,094
1859	471,745	284,041	84,841	840,627
1860	519,211	278,331	122,228	919,770
1861	409,229	195,278	127,037	731,544
1862	470,315	186,660	130,687	787,662
1863	577,638	212,005	157,961	947,604
1864	684,018	241,853	210,125	1,135,996
1865	479,558	262,342	189,682	931,582
1866	749,367	332,580	268,396	1,350,343
1867	798,638	344,341	318,647	1,461,626
1868	893,000	370,000	340,000	1,603,000
1869	971,150	392,150	553,341	1,916,641
1870	930,000	365,000	570,000	1,865,000
1871	956,608	385,000	570,000	1,911,608
1872	1,369,812	500,587	984,159	2,854,558
1873	1,312,754	577,620	977,904	2,868,278
1874	1,202,144	576,557	910,712	2,689,413
1875	908,046	410,990	947,545	2,266,581
1876	794,578	308,649	990,009	2,093,236
1877	934,797	317,843	1,061,945	2,314,585
1878	1,092,870	293,399	1,191,092	2,577,361
1879	1,273,024	358,873	1,438,978	3,070,875
1880	1,807,651	537,558	1,950,205	4,295,414
1881	1,734,462	638,838	2,268,264	4,641,564
1882	2,042,138	697,906	2,438,078	5,178,122
1883	1,885,596	571,726	2,689,650	5,146,972

Some of the pig iron classed above as having been produced with anthracite and bituminous coal, respectively, was produced with a mixture of these fuels, the quantity of pig iron so produced being mainly represented in the anthracite column. The mixed fuel referred to was not used to any considerable extent until within the past few years, and more of it was used in 1883 than in any preceding year. Of the production of 1,885,596 net tons of anthracite pig iron in 1883 not less than 920,142 tons, or nearly one-half of the total quantity, were produced with mixed fuel.

An air-furnace was built at Westham, on the James river, six miles above Richmond, during the Revolution, which is said to have used bituminous coal from Chesterfield county, Virginia, in the manufacture of shot and shells for the Continental army until the furnace was destroyed by Benedict Arnold in 1781.

Bituminous coal was used at an early day in a raw state in the heating furnaces attached to American rolling and slitting mills, and in 1817, when the rolling mill was established at Plumsock, in Fayette county, Pennsylvania, it was so used in both heating and puddling furnaces. In the same year coke was used in a refinery at this mill. It was not, however, until about 1830, when rolling mills became numerous at Pittsburgh, that the use of bituminous coal in these establishments assumed noteworthy prominence.

Before the close of the charcoal era steam had been applied to the blowing of American furnaces, but water-power was still in general use. The necessity of increasing the blast, and other considerations, soon led to the more general use of steam blowing engines in connection with anthracite and bituminous furnaces. Another improvement in blast-furnace management also had its beginning about the close of the charcoal era, namely, the utilization of the combustible gases emitted from blast furnaces. These gases were first used to heat the boilers for the blowing engines, and afterwards to heat the hot-blast stoves.

CHAPTER XXXVII.

THE MANUFACTURE OF BLISTER AND CRUCIBLE STEEL IN THE UNITED STATES.

STEEL was manufactured in a small way in several of the American colonies, either "in the German manner" or by the more clearly defined cementation process. We have in preceding chapters incidentally recorded some of the earliest attempts that were made to establish the manufacture of steel by these primitive methods. In this and the next two chapters we will endeavor to present in sufficient detail the leading facts in the development of the present magnificent steel industry of our country. To do this we must first briefly notice the very insignificance of our small steel industry as it existed in colonial times and long after the close of the Revolutionary struggle.

Bishop states that the first suggestion of the manufacture of steel in the colonies was made in 1655, when John Tucker, of Southold, on Long Island, informed the general court of New Haven "of his abilitie and intendment to make steele there or in some other plantation in the jurisdiction, if he may have some things granted he therein propounds." In October, 1655, and in May, 1656, special privileges were granted to the petitioner, but we are not told whether he ever made any steel or not.

In the chapter relating to the extension of the manufacture of iron in New England we have stated that in 1728 Samuel Higley, of Simsbury, and Joseph Dewey, of Hebron, in Connecticut, represented to the legislature that the first-named had, "with great pains and cost, found out and obtained a curious art, by which to convert, change, or transmute common iron into good steel, sufficient for any use, and was the very first that ever performed such an operation in America." They asked the exclusive right "of practicing the business or trade of steel-making" for twenty years. A patent was granted to them for ten years, provided that "the petitioners improve the art to any good and reasonable perfection within

two years after the date of this act." They do not seem to have succeeded in placing their enterprise on a firm foundation. Mr. Charles J. Hoadly, the librarian of the Connecticut State Library, sends us a copy of the following certificate of two smiths who certified to the excellence of Mr. Higley's steel, which was clearly made by cementation.

THIS may certify all concerned that Samuel Higley of this town of Simsbury came to the shop of us the subscribers being blacksmiths, some time in June in the year one thousand seven hundred and twenty-five, and desired us to let him have a pound or two of iron made at the new works near Turkey Hills, which we according to his desire let him have, shapeing severall peices according to his order. He desired that we would take notice of them that we might know them again, for, said he, I am a going to make Steel of this Iron, and I shall in a few days bring them to you to try for steel. Accordingly he brought the same peices which we let him have, and we proved them and found them good steel, which was the first steel that ever was made in this country that ever we saw or heard of. Since which he hath made farther experiment, taking from us Iron & returning it in good Steel. As witness our hands this 7th day of May, 1728.

TIMOTH PHELPS. JOHN DRAKE.

The mother of Governor Jonathan Trumbull, of Connecticut, ("Brother Jonathan,") was of the Higley family, and John Brown, of Ossawatomie, was descended from the same family.

In October, 1740, the Connecticut legislature granted to Messrs. Fitch, Walker, and Wyllys "the sole privilege of making steel for the term of fifteen years, upon this condition that they should in the space of two years make half a ton of steel." It appears, however, that this condition was not complied with, and the privilege was extended two years longer, or until 1744, before which time Aaron Eliot and Ichabod Miller certified that, "after many expensive and fruitless trials with which sundry of the owners were discouraged, the affair being still pursued by others of them, it has so far succeeded that there has been made more than half a ton of steel at the furnace in Symsbury which was erected for that purpose by the gentlemen to whom the aforesaid grant was made." Fitch, Walker, and Wyllys were not, however, mechanics, the first two being lawyers and the last-named being the secretary of the colony.—These facts we learn from Mr. Hoadly.

Some time previous to 1750 Aaron Eliot owned a steel

furnace at Killingworth, in Middlesex county, Connecticut, and in this furnace he succeeded in 1761 in converting into good steel a bar of iron made in a common bloomary from magnetic sand by his father, the Rev. Jared Eliot, who received a gold medal from the London Society of Arts "for producing malleable iron from the American black sand."

In May, 1772, the following petition was presented to the legislature of Connecticut by Aaron Eliot, for a copy of which we are indebted to Mr. Hoadly.

To the Honl General Assembly now sitting in Hartford. The memorial of Aaron Eliot of Killingworth humbly sheweth,

That your memorialist has for a number of years carried on the Steel Manufacture in this Colony and has made very large quantities, sufficient to supply all the necessary demands of that article in this Colony as well as to export large quantities for supplying the neighbouring governments; that the fortune of your memorialist has not been large enough to supply himself with a sufficient stock to carry on his business, & has therefore hitherto been obliged to procure his stock of iron at New York on credt and pay for the same in his steel when made at the moderate price of £56 per ton, [\$186.66⅔, the £ being equal to \$3.33⅓,] from whence it has been again purchased in this Colony at the price of £75 and £80 per ton, and for several years past almost the whole supply of steel in this Colony has been from New York of the manufacture of your memorialist at the aforesd enormous advance, and your memorialist humbly conceives that the interest of the Colony is to incourage necessary and advantageous manufactories within the Colony, not only for the necessary consumption of the Colony but for export, which your memorialist will be able to effect in the aforesd article of stéel with some small assistance from your Honrs to procure him a sufficient stock and thereby save larger sums of money within this Colony which is annually paid to New York for the steel manufactured in this Colony: Wherefore your memorialist humbly prays your Honours to loan to him £500 out of the publick treasury for three years without interest, whereby he will be enabled to carry on the aforesd business to considerable publick advantage, and he as in duty bound shall ever pray.

AARON ELIOT.

Mr. Eliot's petition was granted in 1772, and in 1775 the loan was continued for two additional years.

In 1750 Massachusetts had one steel furnace. Bishop says that in 1787 the manufacture of steel was introduced into the town of Easton, in Massachusetts, by Eliphalet Leonard. "The article was made in considerable amount, and cheaper than imported steel," but it was inferior to foreign steel for edge tools and cutlery. This was doubtless cemented steel.

About 1797 steel was made at Canton, in the same State, "from crude iron by the German process."

Peter Townsend, who became the proprietor of the Sterling iron works in New York before the Revolution, produced in 1776 the first steel made in that province. It was made "at first from pig and afterwards from bar iron, in the German manner." Blister steel was made in 1810 by Peter Townsend, Jr., which is said to have been of as good quality for the manufacture of edge tools as steel made from Dannemora iron. At Amenia, in Dutchess county, New York, steel was made for the use of the Continental army.

New Jersey had one steel furnace in 1750. Steel was made at Trenton during the Revolution, "but the business afterwards declined."

Pennsylvania had a steel furnace in Chester county, called Vincent's, about 1750, and in that year it had two other steel furnaces at Philadelphia. Concerning one of these, William Branson's, Richard Hockley writes to Thomas Penn on June 3, 1750: "As to steel, Mr. Branson says the sort he made, which was blistered steel, 10 tons would be ten years in selling." The other furnace, Stephen Paschal's, which was built in 1747, was owned in 1787 by Nancarrow & Matlock, when it was visited by General Washington, and is said to have been "the largest and best in America." In 1770 Whitehead Humphreys was the proprietor of a steel furnace on Seventh street, in Philadelphia. During the Revolution he made steel for the Continental army from Andover iron. In 1786 the legislature of Pennsylvania loaned £300 to Mr. Humphreys for five years to aid him in making steel from bar iron "as good as in England."

During the Revolution Henry Hollingsworth, at Elkton, in Cecil county, Maryland, manufactured muskets for the Continental army. Some of his bayonets were complained of as being too soft, "which he ascribed to the bad quality of the American steel with which they were pointed." Bishop does not mention any steel furnace in Maryland, and we are therefore unable to conjecture where Mr. Hollingsworth obtained his poor steel. We are also without positive information concerning the colonial or Revolutionary steel industry of Virginia and other southern colonies. In most of these colonies

bounties were offered at the beginning of the Revolution for the establishment of steel furnaces as well as other manufacturing enterprises.

In the celebrated report of Alexander Hamilton, dated December 5, 1791, it is stated that "steel is a branch which has already made a considerable progress, and it is ascertained that some new enterprises on a more extensive scale have been lately set on foot." In the same year, 1791, in a reply to Lord Sheffield's *Observations on the Commerce of the United States*, Tench Coxe stated that "about one-half of the steel consumed in the United States is home-made, and new furnaces are building at this moment. The works being few, and the importations ascertained, this fact is known to be accurate." The works here referred to were all doubtless cementation furnaces, which produced blister steel.

In 1805 there were two steel furnaces in Pennsylvania, which produced annually 150 tons of steel. One of these was in Philadelphia county. In 1810 there were produced in the whole country 917 tons of steel, of which Pennsylvania produced 531 tons in five furnaces—one at Philadelphia and one each in Philadelphia, Lancaster, Dauphin, and Fayette counties. The remainder was produced in Massachusetts, Rhode Island, New Jersey, Virginia, and South Carolina, each State having one furnace. In 1813 there was a steel furnace at Pittsburgh, owned by Tuper & McKowan, which was the first in that city. Tench Coxe declared in this year that the manufacture of "common steel, iron wire, and edge tools" had been greatly advanced since 1810.

In 1818 John and Jacob Rodgers, Isaac Smedley, and James Wood were engaged in the manufacture of saws at Valley Forge, Pennsylvania, on the Montgomery county side of Valley creek. Mr. Wood was the manager of the works. The company built a furnace in that year for the manufacture of crucible steel for saw plates, John Parkins and his son, John Parkins, Jr., from England, being employed as practical steel-makers. These two persons are said to have made an unsuccessful attempt to make cast steel at New York City in 1812. The company at Valley Forge is said by Mr. Wood's son, Mr. John Wood, of Conshohocken, who is now living, to have made some excellent steel, but the project was

soon abandoned. Clay for crucibles was brought from Perth Amboy, and some plumbago crucibles were imported from England. This is the first important crucible-steel enterprise in our history that has been brought to our notice.

In 1831 a convention of the friends of American industry assembled at New York, at which were submitted many able reports upon the iron and steel industries of the country as they existed at that time. From one of these reports, prepared by Mr. John R. Coates, of Philadelphia, we learn that there were then in the United States fourteen blister-steel furnaces, distributed as follows: two at Pittsburgh, one at Baltimore, three at Philadelphia, three at New York, one in York county, Pennsylvania, one at Troy, New York, two in New Jersey, and one at Boston. The report stated that "these furnaces are known to be now in operation, and of a capacity sufficient to supply more than 1,600 tons of steel annually, an amount equal to the whole importation of steel of every kind." The report continued: "But it should be observed that steel for common agricultural purposes is not the best, although it is most used; and that American is quite equal to English steel used for such purposes in England. American competition has excluded the British common blister steel altogether. The only steel now imported from Great Britain is of a different and better quality than that just mentioned." The common blister steel of American manufacture which is above referred to was used for plow-shares, shovels, scythes, and cross-cut and mill saws.

The better qualities of steel which were not made in this country in 1831, but were imported from Europe, almost entirely from England, were known as (1) best blister steel, made from iron from the Dannemora mines in Sweden; (2) shear steel, of the same origin; and (3) cast steel, made in crucibles. Concerning blister steel of the best quality the report from which we have quoted says that "steel is now made at Pittsburgh, and may be made in New York and Connecticut, bearing, a fair comparison with the best hoop L, or Dannemora steel. No difference is observed where trials have been made without disclosing to the judges the origin of either." The report adds that iron equal to Swedish for the manufacture of steel had been recently manufactured "by improved processes

from the ore of Juniata, and both sides of the line between New York and Connecticut." Shear steel was the best blister steel of the cementation furnace reworked under a hammer into bars convenient for the manufacture of coarse cutlery and edge tools. The manufacture of this steel was then about being introduced into this country. The report says: "England has hitherto monopolized this branch also, from being in possession of the only European steel that would bear the expense of preparation, and from the perfection of her machinery. She has now the honor of transferring a portion of her experience and skill to the United States." Cast steel, which was then made only from the best blister steel, was not made in the United States. Several attempts to make it with profit had been unfortunate in their results. "The causes of failure," says the report, "were, first, the want of the best quality of blister steel at a reasonable price, and, second, the want, or expense, of crucibles of proper quality, wherein the blister steel is to be melted and smelted. Black lead and a variety of clays have been tried, but the weakness of these materials has heretofore caused a loss to the manufacturer." The English Stourbridge clay was the only clay which in 1831 was known to possess the qualities required for crucibles. The report says that "the explorations of the present year have disclosed the existence of clay analogous to that of Stourbridge," the discoveries being made in Centre, Clearfield, and Lycoming counties in Pennsylvania, and in the vicinity of Baltimore. The expectations created by these discoveries were never realized.

From 1831, the date of the report from which we have just quoted, to 1860 but little progress was made in developing the manufacture of the finer qualities of steel in this country; but during this period, indeed just after its commencement, there was one notable and successful attempt to make steel of the best quality, the detailed history of which we shall now give.

In August, 1832, William Garrard and John Hill Garrard, brothers, commenced the manufacture of crucible steel on the Miami Canal, at Cincinnati, in works which had been previously erected by them, and which were projected in the autumn of 1831. Both were comparatively young men, natives

of England, but residents of the United States for ten years previous to the year mentioned. The style of the firm was Garrard Brothers, but William, the elder brother, was the projector and practical manager of the enterprise. The younger brother died at Pittsburgh in 1883, aged 78 years. Dr. William Garrard is still living at Fallston, in Beaver county, Pennsylvania, and to him and to his friend, Mr. James E. Emerson, of Beaver Falls, in the same county, we are indebted for the very full details we are enabled to present of the first successful works in the United States for the manufacture of crucible steel of the best quality. Mr. Emerson has also sent us an illustration of the works, printed from a wood-cut made in 1833. They were called the Cincinnati steel works.

The works were located on Canal street, extending back to Providence street, and were built upon a portion of the ground now occupied by the Lion brewery. They embraced a furnace for converting bar iron into blister steel; two pot-holes, each accommodating two pots, or crucibles; and the necessary machinery for manufacturing saws and files. In August, 1832, the first cast steel was made, and in November of the same year the first mill and cross-cut saws were made. Dr. Garrard writes us as follows:

> I made my own blister steel. You will see in the picture of my works a large round stack that contained my converting furnace. It was built for two ten-ton converting furnaces. The first crucibles I experimented with were German plumbago pots, but they were a failure, as they spoiled the steel by giving out too much gross carbon. I then went to Western Virginia, near New Cumberland, and found a clay that very much resembled English Stourbridge clay, and by putting in the pots made of it about the same proportion of burnt material they stood about as well as the Stourbridge pots, and answered my purpose very well. In respect to the building of my works, I was my own architect, drew a plan for my works on paper, and superintended the brick-laying myself; in fact, the building and machinery were all made from my own drawings and under my own superintendence. I sold my steel and manufactured articles principally to manufacturers. There were some wholesale houses that bought of me, but they were importing houses, and when the Sheffield manufacturers found that I was making as good steel and manufactured saws and files as good as they did they gave our merchants such an extended time of credit that they bought as little as possible from us.

Mr. Emerson furnishes us with the following additional information concerning the Cincinnati steel works.

The Doctor still has his old moulds in which he formed his crucibles, in the regular English way. For best cast steel he first used Swedes' iron. For steel used for saws, springs, etc., he used Tennessee charcoal iron. For best cast steel he also used considerable Missouri charcoal iron. In addition to saws and springs, he made steel for chopping axes, files, and tools in general. The material used was all very high-priced, so that the owners were obliged to sell their spring steel at from 10 to 15 cents per pound, and best cast steel at from 18 to 25 cents. The very crude machinery and manner in which all of the work had to be done added also to the cost.

The enterprise was started during Jackson's first term of office, and about the time that the law was passed for a gradual reduction of duties on all imports for a decade, and with this gradual reduction of duties foreign importation increased, to pay for which the country was drained of money. Manufactures were closed, culminating in the great panic of 1837, at which time the enterprise of our venerable friend went down in the general wreck that engulfed the infant manufactures in their cradles all over the country.

After Garrard Brothers had commenced the manufacture of steel W. T. Middleton became a partner in the enterprise, taking the place of Dr. Garrard's brother. Subsequently Charles Fox, a lawyer, became a partner. After the failure in 1837 the business was continued until 1844 by Dr. Garrard and Mr. Fox, the principal product of the steel works being blister steel.

In the Cincinnati Directory for 1834, published by E. Deming, at No. 5 Johnston's Row, there will be found on page 233 the following announcement: "Steel, Saw, and File Factory, on Plumb Street, near the corporation line, owned by Middleton, Garrard & Co., manufacturers of all kinds of Cast Steel, by steam power. Attached to this establishment is a Saw and File Factory, in which these articles are made equal in quality to those imported."

Mr. Emerson has sent us an old file made in 1833 from the crucible steel of these works, and an old turning-tool made from some of the very first steel made in them in 1832, and used in the works for turning their chilled rolls for sheet steel. He has also sent us other interesting relics of these works, which he thus describes:

At the first available opportunity, after receiving your letter of the 26th of December, I visited the home of Dr. Garrard and secured an old turning tool and an old punch used as a die for cutting teeth in saws, the steel of which the Doctor informed me was made in 1832. I have forged quite a ghastly-looking knife-blade off the end of the old turning tool, and a smaller blade off the end of the saw-tooth punch, and have hardened, temper-

ed, and finished them. I have been working steel for about forty years. At Trenton, New Jersey, during the civil war, I manufactured over 75,000 cavalry sabres and over 100,000 officers' swords for the United States Government, and I think that I know something about steel and about tools. I am willing to submit these tools to any expert and risk my reputation that in quality they are fully equal to the best steel made in this country to-day, and also equal to the best imported English steel. Here is an affidavit from the Doctor:

Personally appeared Dr. William Garrard, of Fallston, Beaver county, Pennsylvania, and being duly sworn deposes and says: That the two pieces of steel from which these two knives were forged, tempered, and finished by Messrs. Emerson, Smith & Co., of Beaver Falls, Pennsylvania, were made by him at Cincinnati, Ohio, in 1832, by first converting Missouri charcoal iron into blister steel by the usual cementation process, then by melting in pots made by himself, pouring into ingots, then forging or tilting in the usual manner. The large piece was used as a lathe turning tool, and the small one as a punch for toothing saws. Furthermore the said William Garrard sayeth not.

Sworn and subscribed before me this 28th day of January, A. D. 1884.

WINFIELD S. MOORE,
[SEAL] *Notary Public.*

WILLIAM GARRARD.

The Doctor has placed in my hands numerous testimonials from manufacturers who used his steel for different purposes—for chopping axes, files, springs, saws, etc.

All of the articles mentioned above are now in our possession, and we prize them highly. An examination of them by experts will fully sustain the claim that they are made of *the best crucible tool steel.*

At our request Mr. J. Blodget Britton, the eminent metallurgical chemist, has made an analysis of liberal borings from the end of the turning tool from which Mr. Emerson has forged the "ghastly-looking knife-blade," this end forming the handle of the knife. The analysis is as follows. It will possess great interest for all of our readers who would know the chemical elements of the first tool steel of best quality this country has produced.

Pure iron	98.770	Manganese	.019
Carbon	1.048	Sulphur	doubtful traces
Silicon	.102		
Silicates	.020	Total	99.974
Phosphorus	.015		

Dr. Garrard was born in Laxfield parish, Suffolk county, England, on the 21st of October, 1803. He removed with his

father's family to the United States in 1822, the whole family finding a home near Pittsburgh. The Doctor says: "It was during the last two years that I was with my father that I built a small converter and experimented on the various kinds of bar iron, converting them into blister steel, and through a careful test of the same I became convinced that I could make steel equal to the English." He was not a trained steel-maker, nor even an iron-maker. His trade was that of a bricklayer, but he had a liking for chemistry, and his attention being turned to the manufacture of steel this taste was utilized. The rest of his story we have told.

The following is a list of all the works in Pennsylvania that were engaged in the conversion of steel in 1850, with their product: James Rowland & Co., Kensington, (Philadelphia,) 600 tons; J. Robbins, Kensington, 500 tons; Earp & Brink, Kensington, 100 tons; Robert S. Johnson, Kensington, 400 tons; W. & H. Rowland, Oxford, (Philadelphia,) 700 tons; R. & G. D. Coleman, Martic, Lancaster county, 400 tons; R. H. & W. Coleman, Castle Fin, York county, 100 tons; Singer, Hartman & Co., Pittsburgh, 700 tons; Coleman, Hailman & Co., Pittsburgh, 800 tons; Jones & Quigg, Pittsburgh, 1,200 tons; Spang & Co., Pittsburgh, 200 tons; G. & J. H. Shoenberger, Pittsburgh, 200 tons; S. McKelvy, Pittsburgh, 178 tons; total, thirteen works, with a product of 6,078 tons. Of this quantity only 44 tons were cast steel. The foregoing information is not found in the census of 1850, but was obtained by an association of Pennsylvania ironmasters. The census of that year greatly understates the extent of our steel industry, and erroneously makes no mention of the manufacture of steel in any other State than Pennsylvania.

From about 1830 to 1860 many attempts were made at Pittsburgh to produce blister and crucible steel. Between 1828 and 1830 Simeon Broadmeadow, an Englishman, and his son made blister steel, and about 1831 they made some cast steel in pots of their own manufacture. The attempt to manufacture cast steel was a failure. Josiah Ankrim & Son, file-makers, are said to have succeeded in making their own steel after 1830, but by what process is not stated. In 1831 Wetmore & Havens successfully produced blister steel. In 1833 the firm of G. & J. H. Shoenberger commenced to manufacture

blister steel, and in 1841 Patrick and James Dunn attempted the manufacture of crucible cast steel for this firm. This last enterprise was abandoned in a year or two. "The crucibles employed were made of American clay, and, as may be supposed, were ill-suited to the purpose required." The firm continued to make blister steel until 1862, when its further manufacture was abandoned. It used Juniata blooms exclusively. About 1840 the firm of Isaac Jones & William Coleman was formed to manufacture blister steel, which business was successfully prosecuted until 1845, when the firm was dissolved, Mr. Jones retiring. In the same year Jones & Quigg built the Pittsburgh steel works, also to manufacture blister steel. Mr. Coleman continued alone the manufacture of blister steel until 1846, when a partnership was formed under the name of Coleman, Hailman & Co. Both of these new firms were successful in making blister steel of good quality. They were also successful in manufacturing some cast steel of a low grade. The first slab of cast plow steel ever rolled in the United States was rolled by William Woods, at the steel works of Jones & Quigg, in 1846, and shipped to John Deere, of Moline, Illinois. About 1846 the firm of Tingle & Sugden, filemakers, made its own steel. This was cast steel. The firm is also reported to have made some cast steel for sale. Juniata iron was used by nearly all of these manufacturers.

In 1852 McKelvy & Blair, of Pittsburgh, who had commenced the manufacture of files in 1850, made cast steel of good quality, but not always of the best quality. It was, however, of a quality so creditable, and so uniformly superior to any that had previously been made at Pittsburgh, that the firm may be regarded as the pioneer in the production of cast steel in large quantities in that city. In 1853 the firm of Singer, Nimick & Co., of Pittsburgh, which had been organized in 1848 for the manufacture of blister steel, and in 1855 Isaac Jones, then doing business in his own name, were successful in producing the usual grades of cast steel for saw, machinery, and agricultural purposes, but they did not make tool steel of the best quality as a regular product. That honor was reserved for the firm of Hussey, Wells & Co., which began business in 1859, and in the following year was successful in making crucible cast steel of the best quality as a regular

product. This was done with American iron. In 1862 the firm of Park, Brother & Co., also of Pittsburgh, accomplished the same achievement, also with American iron. These were the first firms in the country to meet with complete financial as well as mechanical success in this difficult department of American manufacturing enterprise. Their works are still in operation.

For many of the foregoing details concerning the manufacture of steel at Pittsburgh we are indebted to an anonymous publication, entitled *Pittsburgh, its Industry and Commerce,* published in 1870, and to George H. Thurston's *Pittsburgh and Allegheny in the Centennial Year.*

While these experiments in the manufacture of the best qualities of steel were being made at Pittsburgh, other localities were engaged in making similar experiments. By far the most important of these were made by the Adirondack Iron and Steel Company, whose works were at Jersey City, New Jersey. They were built in 1848 to make blister steel from charcoal pig iron made at Adirondack, in Essex county, New York, and also to make cast steel. The pig iron was puddled with wood at Adirondack, and then formed into bars under a hammer, which were sent to Jersey City, where they were converted into blister steel. An attempt to make cast steel by melting the blister steel in clay crucibles was a failure, but subsequently cast steel of good quality was made in black-lead crucibles. This result was reached as early as February, 1849, and possibly a few months earlier. Of the excellent quality of the cast steel manufactured at this time at these works there is abundant evidence in the testimony of government experts and of many consumers, all of which is now before us. It was used for chisels, turning and engravers' tools, drills, hammers, shears, razors, carpenters' tools, etc. Its manufacture was continued with encouraging results until 1853, when the business was abandoned by the company. It had not proved to be profitable, partly because of the prejudice existing against American cast steel. The works were then leased for ten years, during which time they were operated with varying success. James R. Thompson was the manager from 1848 to 1857. In 1863 they were purchased by Dudley S. Gregory, one of the original stockholders, and were

from that time managed with uniform success for the owner by H. J. Hopper. In 1874 Mr. Gregory died, and the works descended to his sons. They are now owned by Andrew Williams. They are the oldest existing cast-steel works in the United States, having been continuously employed in the production of this kind of steel since 1849. Mr. Hopper is still their manager.

It is proper to add that, while good cast steel was made from 1849 at the works of the Adirondack Iron and Steel Company, the product was not for many years of uniform excellence. Much of it was good tool steel, but much of it was also irregular in temper. The exact truth appears to be that the cast steel produced by this company during the early years of trial, or from 1849 to 1853, was more uniformly excellent than that which had been produced by earlier or by cotemporary American steel works, the Cincinnati steel works of Garrard Brothers alone excepted. This excellence was mainly due to the superiority of Adirondack iron. Since 1852 the Adirondack works have had many rivals in the production of crucible cast steel, the earliest of which have already been described.

Mr. Thomas S. Blair, of Pittsburgh, has furnished us with the following reminiscences of the American steel industry as it existed about 1850.

The blister steel made at Pittsburgh was sent all over the West, and was used by the country blacksmiths for the pointing of picks, mattocks, etc., and for plating out into rough hoes, etc. It was usually made from Juniata blooms, especially in the period anterior to 1850. After that date Champlain ore blooms were used to a considerable extent. German steel was simply blister steel rolled down. The two leading applications of German steel were springs and plow-shares. The business was very large at one time. G. & J. H. Shoenberger pushed this brand vigorously from about 1840 to 1860. Meanwhile quite a number of other concerns entered into the competition at various times.

The Shoenberger experiment in the manufacture of crucible steel failed on account of the inferior quality of the product. The firm were so confident that no iron could be found in this country that could in any respect excel the Juniata iron that, when that article failed to produce steel equal to that of Sheffield, they gave up the manufacture of crucible steel. In the light of the experience gained under the scientific methods which the Bessemer process has made a necessity we now understand that the Shoenbergers could not make good crucible steel out of iron containing two-tenths of one per cent. of phosphorus.

McKelvy & Blair at first made their pots out of Darby and Stannington clay, imported from England. The brilliant success of Joseph Dixon, of Jersey City, New Jersey, in perfecting the manufacture of plumbago crucibles, for which the crucible steel interest in the United States owes him a monument, gave to that firm and to the Jersey City steel works a very valuable lift. With these crucibles and with Adirondack blooms Mr. Thompson made some excellent steel. Along in 1853 and 1854 McKelvy & Blair made steel from the Adirondack blooms which was used in the nail factory of G. & J. H. Shoenberger. It may be added, also, that the knives and dies of nail-cutting machines afford an admirable test of endurance in tool steel. The American steel made from American iron was fully up to the English steel in every particular.

It was not possible for McKelvy & Blair to obtain the Adirondack blooms in any quantity, and they had no other resource than the Champlain and Missouri blooms, all of which produced red-short steel. This, notwithstanding that drawback, found a market so extensive that the firm sent to Sheffield and brought out several skilled workmen, and the business of manufacturing handsomely finished bars, plates, and sheets was fairly inaugurated. The drawbacks, however, of pioneer operations, chief among which was the abominable English system, imported along with the skilled labor, of "working to fool the master," were too much for the financial strength of the firm, and in 1854 they were forced to drop the enterprise.

The manufacture in this country of crucible cast steel of the best grades may be said to have been established on a firm basis after Hussey, Wells & Co., Park, Brother & Co., and Gregory & Co., in the years 1860, 1862, and 1863, respectively, succeeded in making it of uniform quality as a regular product. The event was one of great importance, as it marked the establishment in this country of a new industry which was destined to assume large proportions and to be of immense value. It met a want that had long been felt, and dissipated the long-standing belief that this country possessed neither the iron nor the skill required to make good cast steel. The establishment of this new industry, following closely in the wake of our successful application of anthracite and bituminous coal in the manufacture of pig iron, assisted greatly to advance our metallurgical reputation and to create confidence in our future metallurgical possibilities. But none of the three firms named could have succeeded in giving to this country a crucible-steel industry worthy of the name if the Morrill tariff of 1861 and its supplements had not encouraged our manufacturers by imposing for the first time in our history really protective duties on steel of foreign manufac-

ture. Our whole steel industry of every description is indeed in an eminent degree the child of protective legislation.

Fifty years ago, when the convention of the friends of home industry met at New York, we were struggling with the difficulties which then prevented the manufacture of blister steel of best quality; now we have not only solved that problem, but twenty years ago we solved the greater problem of the manufacture of crucible steel, and a few years later we achieved the still greater triumph of firmly planting upon American soil the Bessemer steel industry. To this marvelous industry we have added the manufacture of steel by the open-hearth, or Siemens-Martin, process—a method of producing steel second only to the Bessemer process in cheapness and productiveness.

Yet we might have had and should have had a crucible-steel industry at a much earlier day. The success of Garrard Brothers in manufacturing the best quality of tool steel at Cincinnati from 1832 to 1837, and of the Adirondack Iron and Steel Company in accomplishing the same result at Jersey City in 1848 and for several years afterwards, in both instances from raw materials of domestic production, proves that this country was long prevented from having a creditable crucible-steel industry because the injurious effects of foreign competition were not sufficiently guarded against in the framing of tariff legislation. The compromise tariff of 1833 closed the Cincinnati steel works. The tariffs of 1846 and 1857 gave no encouragement to our people to engage in the manufacture of crucible steel. Even the manufacture of blister steel in this country was almost destroyed by foreign competition prior to 1860. With the establishment after that year of our crucible-steel industry upon a firm basis, through protective legislation, there was no need to revive on a large scale the manufacture of the inferior product, except as an adjunct of the manufacture of crucible steel.

The production of crucible steel in the United States amounted to 89,762 net tons in 1881, which is the highest annual product yet attained. As late as 1877 the production was only 40,430 tons, which had not previously been exceeded in any year.

CHAPTER XXXVIII.

THE MANUFACTURE OF BESSEMER STEEL IN THE UNITED STATES.

THE Bessemer process for the manufacture of steel consists in forcing streams of cold air, usually under a high pressure, into a pear-shaped vessel called a converter, which has been partly filled with melted cast iron, by which operation the oxygen of the air combines with and eliminates the carbon and silicon in the iron, the product being decarbonized and desiliconized iron. But, as some carbon is always required to produce steel, a definite quantity of manganiferous pig iron (spiegeleisen) or ferro-manganese is added to the contents of the converter while they are still in a state of fusion, by which addition the requisite amount of carbon is obtained, while the manganese liberates whatever oxygen may have remained after the termination of the blast. The final product is Bessemer steel, of a quality or temper corresponding to the character and proportions of the materials used. A distinguishing feature of the Bessemer process consists in the entire absence of any fuel whatever in converting the already melted cast iron into steel—the carbon and silicon in the iron combining with the oxygen of the atmospheric blast to produce an intensely high temperature. The Bessemer converter holds from five to fifteen tons. The charge of cast iron which it receives preliminary to a conversion, or "blow," may be supplied directly from a blast furnace or from a cupola in which pig iron has been melted. The latter method is generally employed in both Europe and the United States.

Sir Henry Bessemer, of London, the generally accredited inventor of the process which bears his name, commenced in 1854 to experiment in the manufacture of iron for an improved gun. "In the course of his experiments," says Mr. J. S. Jeans, in his comprehensive work on *Steel*, "it dawned upon him that cast iron might be rendered malleable by the introduction of atmospheric air into the fluid metal." In 1855 and 1856 patents were granted to Mr. Bessemer for this discovery,

but it was not until 1858 that entire success was achieved by him in the conversion of cast iron into cast steel. Nor was this success achieved without the assistance of others, Robert F. Mushet, of Cheltenham, England, and Goran Frederick Goransson, of Sandviken, Sweden, contributing greatly to this result. Without the assistance rendered by Mr. Mushet, of which we shall speak hereafter, Mr. Bessemer's invention would not have been of much value. It may also be added that many and valuable improvements have been made in the application of the Bessemer process since its successful introduction in Europe and America. These improvements, however, detract nothing from the honor that is due to Sir Henry Bessemer, since it is true of all valuable inventions that their value is increased by the ingenuity and skill of those who use them. In addition to discovering that melted cast iron could be decarbonized and desiliconized and rendered malleable by blowing cold air through it at a high pressure, Mr. Bessemer is entitled to the whole credit of inventing the wonderful machinery by which this discovery has been applied to the rapid production of large quantities of Bessemer steel. The purely engineering feats accomplished by him in the development of his invention were essential to its success, and they amaze us by their novelty and magnitude. Those who have never seen this machinery in operation can form but a faint idea of its exquisite adaptation to the purposes to be accomplished. A Bessemer converter, weighing with its contents from twenty to thirty tons, is moved at will on its axis by the touch of a man or boy, and receives, in response to the same touch, a blast so powerful that every particle of its many tons of metallic contents is heated to the highest temperature ever known in the mechanic arts. The honor of inventing this machinery is all Mr. Bessemer's own.

In 1856 Mr. Bessemer obtained two patents in this country for his invention, but was immediately confronted by a claim of priority of invention preferred by William Kelly, an ironmaster of Eddyville, Kentucky, but a native of Pittsburgh, Pennsylvania. This claim was heard by the commissioner of patents and its justice was conceded, the commissioner granting to Mr. Kelly a patent which at once operated as an impediment to the use of the patents granted to Mr. Bessemer. The

effect of this action by the commissioner was to prevent for several years any serious effort from being made to introduce the Bessemer process into this country. As a matter of interest and of history we here give a complete account of Mr. Kelly's invention, prepared for these pages by Mr. Kelly himself.

In 1846 I purchased, in connection with my brother, John F. Kelly, a large iron property in Lyon county, Kentucky, known as the Eddyville iron works; and the beginning of 1847 found the firm of Kelly & Co. fairly under way, making pig metal and charcoal blooms. Our forge contained ten forge fires and two large finery, or run-out, fires.

To the processes of manufacture I gave my first and most serious attention; and, after close observation and study, I conceived the idea that, after the metal was melted, the use of fuel would be unnecessary—that the heat generated by the union of the oxygen of the air with the carbon of the metal would be sufficient to accomplish the refining and decarbonizing of the iron. I devised several plans for testing this idea of forcing into the fluid metal powerful blasts of air; and, after making drawings of the same, showed them to my forgemen, not one of whom could agree with me, all believing that I would chill the metal, and that my experiment would end in failure. I finally fixed on a plan of furnace which I thought would answer my purpose. This consisted of a small blast furnace, about 12 feet high, having a hearth and bosh like a common blast furnace. In this I expected to produce decarbonized metal from the iron ore; but, if I failed in this, I could resort to pig metal and thereby have good fluid metal to blow into. The novelty of this furnace was that it had two tuyeres, one above the other. The upper tuyere was to melt the stock; the lower one was fixed in the hearth near the bottom, and intended to conduct the air-blast into the metal. That portion of the hearth in which the lower tuyere was placed was so arranged as to part from the upper portion, and consisted of a heavy cast-iron draw, lined inside with fire-brick, so that, when the iron was blown to nature by the lower tuyere, the draw could be run from under the hearth, and the iron taken out, carried to the hammer, and forged.

I began my experiments with this furnace in October, 1847, but found it impossible to give it sufficient attention, as I had then commenced to build a new blast furnace, the Suwannee, on our property. This occupied so much of my time that I had but little left in which to attend to my new process. In the year 1851, having finished our new blast furnace, I found myself more at leisure, and again directed my attention to my experiments; and, on looking for the cause of failure in my experimental furnace, found that my chief trouble lay in the melting department, not in the more important matter of blowing into the iron, so that the question presented itself to my mind, Why complicate my experiments by trying to make pig metal in a furnace not at all suited to the business? Why not abandon altogether the melting department and try my experiments at our new blast furnace, where I could have the metal already melted and in good condition for blowing into? I fully believed that I could make malleable iron by this process. In my first efforts with this object in view I built a furnace

consisting of a square brick abutment, having a circular chamber inside, the bottom of which was concave like a moulder's ladle. In the bottom was fixed a circular tile of fire-clay, perforated for tuyeres. Under this tile was an air-chamber, connected by pipes with the blowing engine. This is substantially the plan now used in the Bessemer converter.

The first trial of this furnace was very satisfactory. The iron was well refined and decarbonized—at least as well as by the finery fire. This fact was admitted by all the forgemen who examined it. The blowing was usually continued from five to ten minutes, whereas the finery fire required over an hour. Here was a great saving of time and fuel, as well as great encouragement to work the process out to perfection. I was not satisfied with making refined or run-out metal; my object was to make malleable iron. In attempting this I made, in the course of the following eighteen months, a variety of experiments. I built a suitable hot-blast oven; but, after a few trials, abandoned it, finding the cold-blast preferable, for many reasons. After numerous trials of this furnace I found that I could make refined metal, suitable for the charcoal forge fire, without any difficulty, and, when the blast was continued for a longer period, the iron would occasionally be somewhat malleable. At one time, on trying the iron, to my great surprise, I found the iron would forge well, and it was pronounced as good as any charcoal forge iron. I had a piece of this iron forged into a bar four feet long and three-eighths of an inch square. I kept this bar for exhibition, and was frequently asked for a small piece, which I readily gave until it was reduced to a length of a few inches. This piece I have still in my possession. It is the first piece of malleable iron or steel ever made by the pneumatic process. The variability of results in the working of my experimental furnace was then a mystery which is now explained. An analysis having since been made of all the ore deposits of Suwannee furnace, they were found to embrace cold-short, red-short, and neutral ores. Some of the deposits showed a large percentage of manganese.

I now decided that, if I could not succeed in making malleable iron, I could turn my invention to practical account by putting up a furnace of sufficient capacity to supply our forge with refined or run-out metal, and at the same time continue my experiments as before. The difficulty here was in my blast. The furnace engine, though large and powerful, would not give over 5 pounds' pressure to the square inch. To overcome this difficulty I built a converting vessel and placed it in the pig-bed convenient to the tapping-hole of the hearth. This furnace was circular, built of boiler-plate iron, was about 5 feet high and 18 inches inside diameter; and, instead of blowing up through the bottom, the blast was applied to the sides, above the bottom, through four three-quarter-inch tuyeres. Experience soon proved that a single tuyere, an inch in diameter, answered my purpose best. In this vessel I could refine fifteen hundredweight of metal in from five to ten minutes. Should the blast prove weak, as was often the case, the tuyeres could be snuffed in the same way as in a finery fire. In this way a heavy charge could be worked with a weak blast. This furnace had an opening in the side, about nine inches square, three feet from the bottom, to run in the metal; also a tap-hole to let out the metal into a set of iron moulds such as are used about finery fires. This furnace was found to answer a valuable purpose, supplying a cheap method of making run-out

metal, and, after trying it a few days, we entirely dispensed with the old and troublesome run-out fires.

Our blooms were in high repute, and were almost entirely used for making boiler plates, so that many steamboats on the Ohio and Mississippi rivers were using boilers made of iron treated by this process some years before it was brought out in England. My process was known to every iron-maker in the Cumberland river iron district as "Kelly's air-boiling process." The reason why I did not apply for a patent for it sooner than I did was that I flattered myself I would soon make it the successful process I at first endeavored to achieve, namely, a process for making malleable iron and steel. In 1857 I applied for a patent, as soon as I heard that other men were following the same line of experiments in England; and, although Mr. Bessemer was a few days before me in obtaining a patent, I was granted an interference, and the case was heard by the commissioner of patents, who decided that I was the first inventor of this process, now known as the Bessemer process, and a patent was granted me over Mr. Bessemer.

It will be seen that Mr. Kelly claims for himself the discovery of the pneumatic principle of the Bessemer process several years before it dawned upon the mind of Mr. Bessemer. The validity of this claim can not be impeached. But it must also be said that Mr. Bessemer, with the aid of Mr. Mushet, successfully employed this principle in the production of steel, and that Mr. Kelly did not. The Kelly process produced refined iron of good quality. Furthermore, the machinery with which Mr. Kelly operated his process was not calculated to produce rapidly or at all large masses of even refined iron; whereas Mr. Bessemer's machinery was successful almost from the first experiments that were made with it in producing steel in large quantities and with great rapidity.

Mr. Kelly claimed that his process, if successful in connection with the limited operations of the refinery forge attached to his blast furnace at Eddyville, would be applicable also to the refining of iron for rolling mills, and would take the place of puddling. Some experiments with this end in view were made at the Cambria iron works, at Johnstown, Pennsylvania, in 1857 and 1858, in a converting vessel similar to that now used in the Bessemer process. They were so far successful that Mr. Kelly wrote from Johnstown on the 29th of June, 1858, that he had not "the slightest difficulty in converting crude pig iron into refined plate metal by blowing into it for about fifteen to twenty-five minutes." These experiments were not, however, continued. Mr. Robert W.

Hunt, in his *History of the Bessemer Manufacture in America*, read before the American Institute of Mining Engineers in 1876, says that at Johnstown Mr. Kelly "met with the usual number of encouraging failures." The converting vessel used by Mr. Kelly at Johnstown was built by him. Mr. Hunt says it was "the first Bessemer converter ever erected in America." We give this honor to the Eddyville converter.

Mr. Bessemer's process having failed in 1855 and 1856 to produce any successful result in the manufacture of steel, Robert F. Mushet, then of the Forest steel works, and now of Cheltenham, England, on the 22d of September, 1856, took out a patent for his process of adding to melted cast iron, which had been decarbonized and desiliconized by a pneumatic blast, a melted triple compound of iron, carbon, and manganese, of which compound spiegeleisen was the cheapest and most convenient form. The addition of from one to five per cent. of this compound to the cast iron mentioned at once overcame the obstacle which had been fatal to the success of Mr. Bessemer's invention. Mr. Bessemer had decarbonized and desiliconized melted cast iron, but he had not been able to retain or restore the small quantity of carbon that was necessary to produce steel, and in the oxygen of his powerful blast he had given to the contents of his converter an element that prevented the production of even good iron. Mr. Mushet's invention regulated the supply of carbon and eliminated the oxygen. It must be added that only pig iron that is practically free from phosphorus was found to be adapted to the Bessemer process, even with the assistance of Mr. Mushet's invention.

Pending the publication of Mr. Mushet's patent, early in 1857, and during the erection for him of a blowing apparatus and small converter, provided by the late Samuel Holden Blackwell, of Dudley, Mr. Mushet obtained from the Ebbw Vale Iron Company a supply of Bessemerized hematite cast iron. This he melted in ordinary steel melting-pots, adding to the forty-four pounds' charge of each pot, when melted, two pounds of melted spiegeleisen. From this mixture ingots of from 500 to 800 pounds were cast, and one of these ingots was rolled at the Ebbw Vale iron works into a double-headed rail, which was sent to Derby railway station, on the

Midland Railroad, to be laid down there at a place where iron rails had sometimes to be renewed within three months. This was early in 1857. Sixteen years afterwards, in June, 1873, the rail referred to was taken out. *This was the first Bessemer steel rail ever laid down,* and during its life-time about 1,250,000 trains and a like number of detached engines and tenders passed over it.

Having obtained the blowing apparatus and converter already mentioned, Mr. Mushet was enabled in 1857 to cast small ingots of tool steel by the direct Bessemer process, with the addition of spiegeleisen by his own process. The first charge of Bessemer steel ever made with the addition of spiegeleisen was tapped from the small converter at Mr. Mushet's Forest steel works by a young workman, William Phelps, an iron miner, who is now, if living, a citizen of the United States. Soon afterwards Bessemer steel was produced in England in commercial quantities by Mr. Bessemer and his associates.

In 1858 Mr. Goran Frederick Goransson, a Swedish ironmaster, was enabled by using pure manganesic Swedish pig iron to produce Bessemer steel of excellent quality *without adding spiegeleisen,* the iron used being practically free from phosphorus and sulphur, but having the requisite percentage of manganese. Except in a few instances, when pure manganesic pig iron can be obtained, Mr. Mushet's process still continues to be absolutely essential to the manufacture of Bessemer steel.

In May, 1863, Captain E. B. Ward, of Detroit, Daniel J. Morrell, of Johnstown, William M. Lyon and James Park, Jr., of Pittsburgh, and Z. S. Durfee, of New Bedford, having obtained control of the original patent and other patents of Mr. Kelly, formally organized the Kelly Process Company, Mr. Kelly retaining an interest in any profits which might accrue to the company. The company resolved to establish experimental works, and also to acquire the patent in this country of Mr. Mushet for the use of spiegeleisen as a recarbonizing agent, through which the Bessemer process had been made a success in England. This patent was granted to Mr. Mushet in 1856 in England and in 1857 in this country. Experimental works were accordingly established at Wyandotte,

Michigan, and Mr. Durfee was sent to England to procure an assignment of Mr. Mushet's patent. The latter purpose was effected on the 24th of October, 1864, upon terms which admitted Mr. Mushet, Thomas D. Clare, and John N. Brown, of England, to membership in the Kelly Process Company. On the 5th of September, 1865, the company was further enlarged by the admission to membership of Charles P. Chouteau, James Harrison, and Felix Vallé, all of Saint Louis. The works at Wyandotte were erected and operated under the superintendence of William F. Durfee, a cousin of Z. S. Durfee. In the fall of 1864 William F. Durfee succeeded in making Bessemer steel at the experimental works at Wyandotte, and *this was the first Bessemer steel made in the United States.* A part of the machinery used at the Wyandotte works was certainly an infringement upon Mr. Bessemer's patents.

The control in this country of Mr. Bessemer's patents was obtained in 1864 by John F. Winslow, John A. Griswold, and Alexander L. Holley, all of Troy, New York, Mr. Holley visiting England in 1863 in the interest of himself and his associates. In February, 1865, Mr. Holley was successful at Troy in producing Bessemer steel at experimental works which he had constructed at that place in 1864 for his company. Mr. Mushet's method of recarbonizing the iron in the converter was used at Troy, and this was an infringement of his patent. Mr. Hunt says that, "while at the Wyandotte works steel was made at an earlier date, the Troy establishment was the first to bring the process near to a commercial success."

As the Kelly Process Company could not achieve success without Mr. Bessemer's machinery, and as the owners of the right to use this machinery could not make steel without Mr. Mushet's improvement, an arrangement was effected by which all of the American patents were consolidated early in 1866. Under this arrangement the titles to the Kelly, Bessemer, and Mushet patents were vested in Messrs. Winslow, Griswold, and Morrell, the first two being owners of seven-tenths of the property, and Mr. Morrell holding the other three-tenths in trust for the Kelly Process Company. This arrangement continued until the formation of the Pneumatic Steel Association, a joint-stock company organized under the laws of New York, in which the ownership of the consolidated patents

was continued. Z. S. Durfee acted as the secretary and treasurer of the company. The ownership of the patents has since been vested in the Bessemer Steel Company Limited, an association organized under the laws of Pennsylvania. All the original English and American patents have expired. This company, however, owns other patents which relate to the manufacture of Bessemer steel, and which have not expired. Still other patents are held by individuals.

The consolidation, in 1866, of the various interests above mentioned was followed by a large reduction in fees and royalties, and thenceforward the business of making Bessemer steel was rapidly extended in this country. The order in which the various Bessemer steel works of the United States have been established down to 1884 is presented below.

1. Kelly Pneumatic Process Company, Wyandotte, Wayne county, Michigan. One 2½-ton experimental converter. Made its first blow in the fall of 1864. Bought by Captain E. B. Ward in 1865, and abandoned in 1869. These experimental works were connected with an iron rolling mill.

2. Albany and Rensselaer Iron and Steel Company, Troy, New York. Experimental Bessemer plant established by Winslow, Griswold & Holley. One 2½-ton converter. Made its first blow February 15, 1865. Now two 7-ton converters. Added to an iron rail mill.

3. Pennsylvania Steel Works, Pennsylvania Steel Company, Steelton post-office, Dauphin county, Pennsylvania. Two 7-ton converters. Made its first blow in June, 1867. An entirely new works. Three 8-ton converters added in 1881.

4. Freedom Iron and Steel Works, Lewistown, Mifflin county, Pennsylvania. Two 5-ton converters. Made their first blow May 1, 1868. Added to the forge and blast furnaces of the Freedom Iron Company. Failed in 1869 and Bessemer works dismantled; most of the machinery went to Joliet, Illinois.

5. Cleveland Rolling Mill Company, Cleveland, Ohio. Two 6¼-ton converters. Made its first blow October 15, 1868. Now two 10-ton converters. Added to an iron rail mill.

6. Cambria Iron and Steel Works, Cambria Iron Company, Johnstown, Pennsylvania. Two 6-ton converters. Made its first blow July 10, 1871. Added to an iron rail mill.

7. Union Steel Company, Chicago, Illinois. Two 6-ton converters. Made its first blow July 26, 1871. Added to an iron rail mill.

8. North Chicago Rolling Mill Company, Chicago, Illinois. Two 6-ton converters. Made its first blow April 10, 1872. Added to an iron rail mill.

9. Joliet Steel Works, Joliet Steel Company, Joliet, Illinois. Two 8-ton converters. Made its first blow January 26, 1873, and its first steel rail March 15, 1873. An entirely new works.

10. Bethlehem Iron Company, Bethlehem, Pennsylvania. Two 7-ton

converters. Made its first blow October 4, 1873, and its first steel rail October 18, 1873. Now four 7-ton converters. Added to an iron rail mill.

11. Edgar Thomson Steel Works, Carnegie Brothers & Company Limited, Bessemer station, Allegheny county, Pennsylvania. Two 7-ton converters. Made their first blow August 25, 1875, and their first steel rail September 1, 1875. An entirely new works. Now three 10-ton converters.

12. Lackawanna Iron and Steel Works, Lackawanna Iron and Steel Company, Scranton, Lackawanna county, Pennsylvania. Two 5-ton converters. Made its first blow October 23, 1875, and its first steel rail December 29, 1875. Added to an iron rail mill.

13. St. Louis Ore and Steel Company, St. Louis, Missouri. Two 7-ton converters. Made its first blow September 1, 1876. Added to an iron rail mill.

14. Pittsburgh Bessemer Steel Company Limited, Homestead, Allegheny county, Pennsylvania. Two 4-ton converters. Made its first blow March 19, 1881, and its first steel rail August 9, 1881. An entirely new works.

15. Pittsburgh Steel Casting Company, Pittsburgh, Pennsylvania. One 5-ton converter. Made its first blow August 26, 1881. Added to a crucible steel works. Product, ingots for special purposes and steel castings; works not intended for the production of rails.

16. Colorado Coal and Iron Company, South Pueblo, Pueblo county, Colorado. Two 5-ton converters. Made its first blow April 11, 1882. An entirely new works.

17. North Chicago Rolling Mill Company, South Chicago, Illinois. Three 10-ton converters. Made its first blow June 14, 1882. An entirely new works.

18. Scranton Steel Company, Scranton, Lackawanna county, Pennsylvania. Two 4-ton converters. Made its first blow March 29, 1883, and its first steel rail May 4, 1883. An entirely new works.

19. Bellaire Nail Works, Bellaire, Belmont county, Ohio. Two 4-ton converters. Made their first blow April 28, 1884. Added to an iron rolling mill. Product, ingots to be rolled into steel nail plate.

20. Worcester Steel Works, Worcester, Worcester county, Massachusetts. Two 4-ton converters. Made their first blow June 2, 1884. Added to an iron rolling mill.

21. Riverside Iron Works, Wheeling, West Virginia. Two 5-ton converters. Made their first blow June 11, 1884. Added to an iron rolling mill. Product, ingots to be rolled into steel nail plate.

22. Benwood Iron Works, Benwood, Marshall county, West Virginia. Building in 1884 two 4-ton converters, for the production of ingots to be rolled into steel nail plate.

23. Oliver Brothers & Phillips, Pittsburgh, Pennsylvania. One 2-ton Clapp-and-Griffith stationary converter. Added to an iron rolling mill in 1884. Building another converter of the same size.

A summary of the above details shows that twenty-two Bessemer works have been built in this country, of which two have been abandoned. One new works is now being built. The

twenty works that are now or have recently been in operation employ forty-five converters.

Mr. Robert W. Hunt informs us that the first conversion made at Troy was from Crown Point charcoal pig iron, melted in a reverberatory furnace, and we are told by Mr. W. F. Durfee that the first steel made at Wyandotte was converted from Lake Superior charcoal pig iron, melted in a reverberatory furnace, although on a number of subsequent occasions the metal for conversion was taken directly to the converter from the Eureka charcoal blast furnace.

It is supposed that the first attempt made in the world to melt pig iron in a cupola for conversion into steel by the Bessemer process was made by Mr. Z. S. Durfee at the works at Wyandotte during the spring of 1865. This attempt failed of success, owing to the small size of the cupola and the length of time required to accumulate enough iron in the traveling ladle for use in the converter; but the present general employment of the cupola whenever pig iron is used for conversion into Bessemer steel is sufficient evidence that the thought which prompted this first experiment had a substantial and practical foundation. Mr. Hunt states that on July 20, 1865, Mr. Holley successfully used the cupola at Troy in connection with the Bessemer process. The English practice at this time was to use the reverberatory furnace.

Although Bessemer steel is adapted to all purposes for which other steel is used, except perhaps the manufacture of fine cutlery, its use in Europe has been mainly confined to the production of railway bars, and its use in this country has been even more narrowly limited to the same product. For many years after the introduction of the Bessemer process in the United States it was used to produce nothing but rails. In both hemispheres it is now widely used for other purposes.

The first Bessemer steel rails ever made in this country were rolled at the North Chicago rolling mill on the 24th of May, 1865, from ingots made at the experimental steel works at Wyandotte under the supervision of William F. Durfee, superintendent. The rolls with which the blooms were rolled at the North Chicago rolling mill had been in use for rolling iron rails. The steel rails came out sound and well-shaped. Several of these rails were laid in the track of one

of the railroads running out of Chicago, and were still in use in 1875. The American Iron and Steel Association was in session at Chicago at the time, and several of its members witnessed the rolling of the rails.

The following letter from Mr. O. W. Potter, of Chicago, written to Mr. William F. Durfee in 1865, two days after the rolling of the first American steel rails in that city, is of historical value.

OFFICE OF THE CHICAGO ROLLING MILL, CHICAGO, May 26, 1865.

MY DEAR DURFEE: The meeting of the iron and steel men adjourned yesterday to meet in Cleveland the fourth Wednesday in August. I regret very much you could not have been here, particularly to see how well your steel behaved, and you must allow me to congratulate you upon its entire success, and I assure you I was but too proud for your sake that everything *we* had to do with it proved so very successful. The hammer was altogether too light of course, and it took more time than it otherwise would to draw the ingot down, yet all the pieces worked beautifully, and we have made six good rails from the ingots sent over, and not one bad one in any respect. The piece you sent over forged is now lying *in state* at the Tremont House, and is really a beautiful rail, and has been presented to the Sanitary Fair by Captain Ward. We rolled three rails on Wednesday and three on Thursday. At the first rolling only your cousin and George Fritz were present; at the rolling yesterday were Senator Howe, of Wisconsin; B. F. Jones, of Pittsburgh; R. H. Lamborn, of Philadelphia; Mr. Phillips, of Cincinnati; Mr. Swift, of Cincinnati; Mr. Kennedy, of Cincinnati; Mr. May, of Milwaukee, and three ladies; Mr. Scofield, of Milwaukee; Mr. Fritz, of Johnstown; and Mr. Thomas, of Indianapolis, with four strangers. Everything went so well I really wanted you to see some of the good of your labors for so long a time and under such trying circumstances. You have done what you set out to do, and done it well, and I am glad to congratulate you and rejoice with you, for I can appreciate some of your difficulties, and wanted you to hear some of the praises bestowed upon your labors as you richly deserve. I know this would make no sort of difference to you, yet we all have vanity enough (especially in such cases as this) to feel gratified at any little compliments we know we are entitled to, but I will not tire you with any more, as your cousin [the late Z. S. Durfee] can tell you all and more than I can write, but with kindest regards allow me to remain

Yours Most Obt., O. W. POTTER.

The first steel rails ever rolled in the United States upon order, in the way of regular business, were rolled by the Cambria Iron Company, at Johnstown, Pennsylvania, in August, 1867, from ingots made at the works of the Pennsylvania Steel Company, near Harrisburg, Pennsylvania; and by the Spuyten Duyvil Rolling Mill Company, at Spuyten Duyvil, New York, early in September of that year, from ingots made

at the Bessemer steel works at Troy, New York, then owned by Winslow & Griswold.

Mr. Mushet's English patent for the use of spiegeleisen as a recarbonizer was permitted to lapse through causes over which he had no control, and before he had received any pecuniary benefit from his invention. Mr. Bessemer has, however, since recognized his indebtedness to Mr. Mushet's invention by allowing him an annuity of £300, and the Iron and Steel Institute of Great Britain in 1876 awarded to him the Bessemer gold medal for that year, in recognition of the great value of his invention. Mr. Bessemer's profits from his own invention have been enormous. Mr. Jeans says that "from first to last Bessemer's patents have brought him royalties to the value of over £1,057,000." This statement was made in 1879. Mr. Jeans also gives some interesting particulars concerning the profits of the first company that was organized in England to work the Bessemer process. Mr. Bessemer was the projector of this company and a member of it, his associates being Messrs. Longsdon, Allen, and the Galloways of Manchester. The works were located at Sheffield. Mr. Jeans' statement is as follows:

> On the expiration of the fourteen years' term of partnership of this firm, the works, which had been greatly increased from time to time, entirely out of revenues, were sold by private contract for exactly twenty-four times the amount of the whole subscribed capital, notwithstanding that the firm had divided in profits during the partnership a sum equal to fifty-seven times the gross capital, so that by the mere commercial working of the process, apart from the patent, each of the five partners retired, after fourteen years, from the Sheffield works with eighty-one times the amount of his subscribed capital, or an average of nearly cent. per cent. every two months—a result probably unprecedented in the annals of commerce.

The British Government has conferred upon Mr. Bessemer the honor of knighthood in recognition of the value of the invention which bears his name.

Important improvements upon Mr. Bessemer's machinery have been invented and patented by A. L. Holley, George Fritz, Robert W. Hunt, William R. Jones, and other American engineers. Of these improvements the most notable is the Fritz blooming mill, which is in general use in this country and in Europe. The largest number of improvements were made by Mr. Holley. The inventive genius and rare me-

chanical skill of John Fritz have also produced many valuable improvements which were clearly patentable but have not been patented.

In the early stages of the Bessemer steel industry in this country great difficulty was experienced in obtaining suitable pig iron, and also materials for the lining of the converters. The lack of experienced workmen was also severely felt. All difficulties, however, have long been overcome. It is now universally admitted that in the United States this industry has been brought to a higher state of perfection than it has attained in any other country. The American Bessemer steel works have been constructed after plans which are in the main greatly superior to those of European works.

The most recent improvement upon the Bessemer process is the work of two English chemists, Sidney Gilchrist Thomas and Percy C. Gilchrist, both of London. It renders possible the use in the converter of cast iron which contains a large percentage of phosphorus, no method of eliminating from it this hostile element having previously been in use. The first patent of Mr. Thomas, the principal inventor of this successful method of dephosphorizing iron, is dated November 22, 1877, and relates to the application of a lime lining to the Bessemer converter and to the use of lime in combination with its melted contents. The Thomas-Gilchrist process is now employed with success in Great Britain, France, Germany, Austria, Belgium, and Russia, but it has met with the greatest favor in Germany. It has been introduced in this country at the works of the Pennsylvania Steel Company, near Harrisburg. The entire control in the United States of the Thomas-Gilchrist patents, or basic Bessemer process, has been purchased by the Bessemer Steel Company Limited.

Mr. George J. Snelus, of England, claims to have solved the problem of dephosphorization in the same way as Messrs. Thomas and Gilchrist solved it, and some time before their attention was turned to the subject. His invention was patented in 1872. A consolidation of his interests with those of Messrs. Thomas and Gilchrist was effected without difficulty. Jacob Reese, of Pittsburgh, Pennsylvania, also claims priority over Messrs. Thomas and Gilchrist in the invention of the basic process, and this claim is now a subject of controver-

sy in this country. It rests upon patents which were granted to him in this country in 1866. Mr. James Henderson, of New York City, made many interesting experiments in the use of lime as a dephosphorizer before even Mr. Snelus had conceived that it could accomplish this result. Mr. Henderson took out a patent in England for his invention in 1870, and his process was used with satisfactory results at Du Motay's experimental works in Belgium in the summer of 1872. The pig iron that was dephosphorized and converted was obtained at the Bowling works, in England. Colonel J. B. Kunkel, of Frederick county, Maryland, took out letters-patent in the United States in 1876 for the elimination of phosphorus from pig iron by the use of magnesian limestone in the blast furnace. He also claimed that by the use of this agent pig iron could be freed from phosphorus while being refined into iron or steel.

The American Iron and Steel Association has ascertained as follows the production of Bessemer steel rails in the United States since the commencement of their manufacture in this country in 1867 as a commercial product.

Years.	Net tons.	Years.	Net tons.	Years.	Net tons.
1867	2,550	1873	129,015	1879	683,964
1868	7,225	1874	144,944	1880	954,460
1869	9,650	1875	290,863	1881	1,330,302
1870	34,000	1876	412,461	1882	1,438,155
1871	38,250	1877	432,169	1883	1,286,554
1872	94,070	1878	550,398		

The total production of rails in these seventeen years was 7,839,030 net tons. Since 1872 the Association has annually ascertained the production of Bessemer steel ingots in the United States. It has been as follows:

Years.	Net tons.	Years.	Net tons.	Years.	Net tons.
1872	120,108	1876	525,996	1880	1,203,173
1873	170,652	1877	560,587	1881	1,539,157
1874	191,933	1878	732,226	1882	1,696,450
1875	375,517	1879	928,972	1883	1,654,627

A comparison of the production of ingots and rails since 1872 will show approximately the quantity of Bessemer steel

that has annually been used in miscellaneous forms. Virtually all of the Bessemer steel that has ever been produced in this country has been used at home; only an infinitesimal quantity has been exported.

The following table shows the production of Bessemer steel ingots in the United States and in Great Britain since 1880.

Countries.	1880. Gross tons.	1881. Gross tons.	1882. Gross tons.	1883. Gross tons.
Great Britain	1,044,382	1,441,719	1,673,649	1,553,380
United States	1,074,262	1,374,247	1,514,687	1,477,345

The following table shows the production of Bessemer steel rails in the United States and in Great Britain since 1880.

Countries.	1880. Gross tons.	1881. Gross tons.	1882. Gross tons.	1883. Gross tons.
United States	852,196	1,187,770	1,284,067	1,148,709
Great Britain	739,910	1,023,740	1,235,785	1,097,174

The establishment of the Bessemer steel industry in many countries in late years is justly regarded as constituting a much more important revolution in the production and use of iron and steel than had been created by any preceding influence or combination of influences in any age of the world's history.

The following persons who were prominently identified with the introduction of the Bessemer steel industry into this country have passed to the other world, leaving behind them a record of mechanical achievements and business attainments of which their countrymen may well be proud.

John A. Griswold was born at Nassau, Rensselaer county, New York, on November 14, 1818, and died at Troy, New York, on October 31, 1872, aged almost 54 years.

George Fritz was born in Londonderry township, Chester county, Pennsylvania, on December 15, 1828, and died at Johnstown, Pennsylvania, on August 5, 1873, aged almost 45 years.

E. B. Ward was born in Canada, of Vermont parents, on December 25, 1811, and died suddenly at Detroit, Michigan, on January 2, 1875, aged over 63 years.

Z. S. Durfee was born at Fall River, Massachusetts, on April 22, 1831, and died at Providence, Rhode Island, on June 8, 1880, aged over 49 years.

Alexander L. Holley was born at Lakeville, Connecticut, on July 20, 1832, and died at Brooklyn, New York, on January 29, 1882, aged nearly 50 years.

James Park, Jr., was born at Pittsburgh, Pennsylvania, on January 11, 1820, and died at Allegheny City, Pennsylvania, on April 21, 1883, aged over 63 years. A biographical sketch of Mr. Park will be found in *The Bulletin of The American Iron and Steel Association* for May 2, 1883.

CHAPTER XXXIX.

THE MANUFACTURE OF OPEN-HEARTH STEEL IN THE UNITED STATES.

THE open-hearth process for the manufacture of steel, of which the Siemens-Martin furnace is the most popular type, consists in melting pig iron in a large dish-shaped vessel, or reverberatory furnace, and afterwards decarbonizing it by adding wrought iron, steel scrap, or iron ore, a deficiency of carbon being supplied, as in the Bessemer process, by the application of spiegeleisen or ferro-manganese; the product is steel, containing any percentage of carbon that may be desired. The materials are melted by the union in the furnace of atmospheric air and combustible gases, affording an intense heat. All of the heat employed is obtained by the use of a regenerative gas furnace. The melted pig iron, previous to receiving the decarbonizing ingredients, is termed a "bath." The quantity of steel that may be made at one operation, or "heat," ranges from five to fifteen tons, according to the size of the furnace.

The open-hearth process, although capable of producing as large masses of steel as the Bessemer process, is much slower in its operation, but it possesses the advantage over its rival that the melted mixture may be indefinitely kept in a state of fusion until experiments with small portions determine the exact conditions necessary to produce a required quality of steel. Another point of difference may be mentioned. While the distinctive features of both the Bessemer and the open-hearth processes embrace strictly chemical operations on a large scale, no direct manipulation of the contents of the Bessemer converter or open-hearth furnace being necessary, it is worthy of notice that the success of the former mainly rests upon the wonderful power and perfection of the machinery by which it is operated, and the success of the latter mainly rests upon the appliances for producing and storing up the gases used in producing combustion.

Both processes may be combined with already-existing

iron rolling mills or crucible steel works, but the open-hearth process can be most economically added to such establishments, and this is one cause of its increasing popularity, although, as already intimated, its productive capabilities are much less than those of the Bessemer process. The open-hearth process is also especially adapted to the utilization of the scrap steel and rail ends which accumulate at Bessemer steel works, and very naturally, therefore, many open-hearth furnaces have been built in connection with these works, both in Europe and in the United States. Another use to which the open-hearth process is adapted is the remelting of worn-out steel rails for the production of either new steel rails or steel in other forms. A popular use of the open-hearth process in Europe and America is the production of steel plates for boilers. In Europe open-hearth steel is also largely used as a substitute for iron in shipbuilding. It is also coming into use for the latter purpose in this country.

The importance of the two processes which have been mentioned, and the extent of the revolution they have effected, may be inferred from the fact that they have unitedly increased the world's production of steel at least fifty-fold in the last twenty-five years.

Previous to 1856, the same year in which Mr. Bessemer obtained his most important patent, (February 12, 1856,) Dr. Charles William Siemens devoted his inventive genius, in conjunction with his brother, Frederick Siemens, both of whom were natives of Hanover, in Germany, but at the time were citizens of England and residents of London, to the construction of a gas furnace for the manufacture of iron, steel, glass, and other products which require a high and uniform heat. These gentlemen were in that year successful in perfecting the Siemens regenerative gas furnace, which has since been widely introduced in Europe and in this country, and without which no open-hearth steel can be made. The first patent in connection with this invention was granted in 1856 to Frederick Siemens alone.

As early as 1861 Dr. Siemens experimented with the regenerative furnace in the production of cast steel in a reverberatory furnace, or open-hearth, for which application of the regenerative furnace he obtained a patent. He subsequently

encountered great practical difficulties in establishing his process of making steel, efforts to accomplish this result being made in 1862 at Tow Law, and in 1863 and 1864 at Barrow and Fourchambault, the last-named place being in France and the other places in England.

In 1864 Messrs. Emile and Pierre Martin, of the Sireuil works, in France, with the assistance of Dr. Siemens, erected one of the Siemens regenerative gas furnaces to melt steel in an open-hearth, or reverberatory furnace, of their own construction. In this furnace they produced cast steel of good quality and various tempers, and at the Paris Exposition of 1867 their product secured for them a gold medal. Previous to this time and subsequently the Messrs. Martin obtained patents for various inventions which were applicable to the manufacture of steel by the Siemens regenerative furnace. Their principal patent, describing the combined process of decarbonization and recarbonization, was obtained in France in 1865.

Dr. Siemens claims, in a letter which is now before us, that both at Tow Law and Fourchambault cast steel had been produced from pig iron, spiegeleisen, and scrap iron upon an open-hearth, which had been specially constructed by himself for that purpose, *previous* to the Messrs. Martin's connection with the process. The furnace at Tow Law was a small one, and several such furnaces were recently at work there in the manner originally designed by Dr. Siemens. In 1865 Dr. Siemens commenced the erection at Birmingham, in England, of steel works of his own, in which the regenerative furnace should be used in producing steel. These works, which were completed in 1867, have produced satisfactory results.

The Messrs. Martin devoted their efforts to the production of steel by the use of wrought iron and steel scrap, and iron ore also, as decarbonizers in a bath of pig iron, while the efforts of Dr. Siemens were more especially directed to the production of steel by the use of iron ore alone as a decarbonizer in a bath of pig iron, the ore being either in the raw state or in a more or less reduced condition. Until recently the "pig and ore" method was generally employed in Great Britain. The "pig and scrap" method is chiefly used on the

Continent and in this country. In Great Britain a combination of both methods is to-day in use. Under an agreement between the Messrs. Martin and Dr. Siemens the open-hearth process as developed by them was called on the Continent the Martin-Siemens process and in Great Britain the Siemens-Martin process. In this country this process is uniformly styled the Siemens-Martin process. The credit of introducing the "pig and scrap" method into this country is due to the Hon. Abram S. Hewitt, of New York, who was favorably impressed with it when visiting the Paris Exposition in 1867 as a commissioner of the United States. At his request Frederick J. Slade, his assistant, went to Sireuil to study the process that it might be put into practice in this country.

Dr. Siemens and the Messrs. Martin obtained patents in this country for the use of their respective processes for manufacturing steel, and Dr. Siemens also obtained American patents for the Siemens gas furnace. The validity of the Martin patents in this country has yet to be decided by the courts.

The open-hearth process in the manufacture of steel did not originate with either Dr. Siemens or the Martins, having been proposed and experimented with by various other inventors prior to their connection with it, among whom Josiah Marshall Heath was most prominent as early as 1845, but it is eminently just to add that it was not made a success until the great heat supplied by the Siemens regenerative gas furnace was applied to it.

In the conversion into steel of the raw materials used in the open-hearth process the invention of Mr. Mushet, described in the preceding chapter, is indispensable. The dephosphorizing process of Messrs. Thomas and Gilchrist is also applicable to the manufacture of steel in the open-hearth when the materials to be used contain a large proportion of phosphorus.

On the 1st of December, 1862, Park, McCurdy & Co., of Pittsburgh, sent Lewis Powe, the manager of their copper works, to England to study the manufacture of tin plates. While there he visited Birmingham, and saw a Siemens gas furnace and procured one of the Siemens pamphlets containing a full description of it. On his return home he called the attention of James Park, Jr., to the advantages of the fur-

nace. Immediately after July 4, 1863, the erection of a Siemens gas furnace was commenced at the copper works. This furnace was erected for the purpose of melting and refining copper, and was completed on the 14th of August, 1863. It was constructed after the drawings contained in the Siemens pamphlet, and worked well. In the fall of 1863 Mr. Powe revisited England, and while there had an interview with Dr. Siemens. Soon afterwards the firm of Park, Brother & Co. built a Siemens furnace to heat steel, but it was not a success. In 1864 James B. Lyon & Co., of Pittsburgh, built a Siemens gas furnace for making glass. The enterprise, however, although mechanically successful, met with an accident which suddenly brought it to an end. This furnace was also constructed after published designs. The introduction into this country of the Siemens furnace by each of the above-named firms was accomplished in an irregular manner, without first obtaining licenses from Dr. Siemens.

The first Siemens gas furnace that was regularly introduced into this country for any purpose was built by John A. Griswold & Co., at Troy, New York, and was used as a heating furnace in their rolling mill, the license having been granted on the 18th of September, 1867. The next gas furnace that was regularly introduced was used as a heating furnace by the Nashua Iron and Steel Company, of New Hampshire, the license for which was granted on the 26th of September, 1867. The next furnace that was regularly introduced was built by Anderson & Woods, of Pittsburgh, for melting steel in pots, the license for which was dated in November, 1867. About 1869 the owners of the Lenox plate-glass works in Massachusetts also built a Siemens gas furnace. All of these furnaces gave satisfaction.

The first open-hearth furnace introduced into this country for the manufacture of steel by the Siemens-Martin process was built in 1868 by Frederick J. Slade for Cooper, Hewitt & Co., proprietors of the works of the New Jersey Steel and Iron Company, at Trenton, New Jersey. The building of this furnace was commenced in the spring of 1868, and in December of the same year it was put in operation.

The first successful application in this country of the Siemens regenerative gas furnace to the puddling of iron was

made under the direction of William F. Durfee, at the rolling mill of the American Silver Steel Company at Bridgeport, Connecticut, in 1869. Prior to this event an unsuccessful attempt was made to accomplish the same result at the Eagle rolling mill of James Wood & Co., on Saw Mill run, near Pittsburgh.

The production of open-hearth steel in the United States in 1872 was only 3,000 net tons, and in 1873 it was only 3,500 tons. The production of open-hearth steel in this country in the census year 1880 was 84,302 net tons, only 9,105 tons of which were converted into rails, the remainder being used for miscellaneous purposes. At the close of the census year 1880 there were thirty-seven open-hearth furnaces in the United States, of which two were in Illinois, one was in Kentucky, four were in Massachusetts, one was in New Hampshire, one was in New Jersey, ten were in Ohio, fourteen were in Pennsylvania, one was in Rhode Island, two were in Tennessee, and one was in Vermont. Since 1880 this branch of our steel industry has been considerably expanded, our production of open-hearth steel in 1882 amounting to 160,542 net tons. In 1883 the production declined to 133,679 tons. Our open-hearth steel industry is already an important factor in supplying the domestic demand for steel for all purposes for which Bessemer steel and the ordinary qualities of crucible steel may be used. This industry is destined to be still further developed in the immediate future.

The Pernot furnace is a modification of the open-hearth process which has been introduced into the United States from France, but, while producing good steel, it is not likely to grow in favor because of the great trouble and expense which are necessary to keep it in working order. The Ponsard furnace is another modification, but it has not been experimented with in this country, and is not likely to be.

Experimental works were erected at Pittsburgh in 1877 by Park, Brother & Co., in conjunction with Miller, Metcalf & Parkin, for the manufacture of refined iron directly from the ore by a process invented by Dr. Siemens, and successfully tested by him at his experimental works at Towcester, England. The process embodies the application of the Siemens gas furnace. The experiment was abandoned in 1879, the re-

sults being unsatisfactory. The same process was subsequently applied at Tyrone Forges, in Pennsylvania, by Anderson & Co., of Pittsburgh. In 1881 Robert J. Anderson and his associates, under the name of the Siemens-Anderson Steel Company, erected extensive works of the same character at Pittsburgh. Neither the enterprise at Tyrone Forges nor the last-mentioned enterprise at Pittsburgh was long in operation. This process, like many other processes for the manufacture of iron or steel directly from the ore, has its reputation yet to make.

The distinguished scientist, Dr. Charles William Siemens, died suddenly in London, on November 20, 1883, of rupture of the heart, produced by a fall in Park Lane. He was born at Lenthe, in Hanover, on the 4th of April, 1823, and was consequently in his 61st year at the time of his death. In April of the year in which he died the honor of knighthood was conferred upon him, and he was thereafter known as Sir William Siemens.

CHAPTER XL.

MISCELLANEOUS FACTS RELATING TO THE DEVELOPMENT OF THE AMERICAN IRON INDUSTRY.

It would far transcend the limits assigned to this work if all of the modern inventions connected with the manufacture of iron and steel in this country were to be made the subject of historical and statistical inquiry. The most conspicuous of these inventions, and the history of their introduction into our country, have been referred to in preceding chapters. Several subjects of less prominence, but not all of them of less importance, relating to the mechanical development of our iron and steel industries will now be noticed, with which notice this branch of our subject will be dismissed.

Since the introduction into this country of the hot-blast in connection with the manufacture of pig iron, which occurred in the decade between 1830 and 1840, many methods of heating the air have been in use. The first practical application of the hot-blast in this country was made at Oxford furnace, in New Jersey, in 1834, by William Henry, the manager. The waste heat at the tymp passed over the surface of a nest of small cast-iron pipes, through which the blast was conveyed to the furnace. The temperature was raised to 250° Fahrenheit, and the product of the furnace was increased about 10 per cent. In 1835 a hot-blast oven, containing cast-iron arched pipes, was placed on the top of the stack by Mr. Henry, and heated by the flame from the tunnel-head. By this means the temperature of the blast was raised to 500°. This innovation in American blast-furnace practice increased the product of Oxford furnace about 40 per cent., with a saving of about the same percentage of fuel. No better device for heating the blast was in use in this country until about 1840. Hot-blast ovens, supplied with cast-iron arched pipes, of various patterns, were in general use in subsequent years down to about 1861, when an improvement in the construction of the oven, but embodying no essential modification of the system, was introduced by Samuel Thomas and adopted

at many furnaces. In 1867 or 1868 John Player, of England, introduced his iron hot-blast stove into the United States, which soon became popular, owing to the facilities which it afforded for increasing the heat of the blast. Mr. Player personally superintended the erection of the first of his stoves in this country. It was erected at the anthracite furnace of J. B. Moorhead & Co., at West Conshohocken, in Montgomery county, Pennsylvania, and is still in use. Down to the introduction of the Player hot-blast the ovens, or stoves, were generally placed at the tunnel-head; Mr. Player placed his stove on the ground.

It is due to the memory of John Player that the fact should here be plainly stated that the introduction of his stove was the means of greatly increasing the yield of American furnaces and decreasing the quantity of fuel used to the ton of pig iron. After its introduction the temperature of the blast was generally raised, even where the Thomas and other ovens were used, and ere long powerful blowing engines were more generally used and higher furnaces were built. Connellsville coke was found to work admirably as a fuel for blast furnaces in connection with a powerful blast and high temperature. Since 1868 cast-iron stoves of various patterns have been increased in size, and in this and other improvements their efficiency in raising the temperature of the blast has been greatly promoted.

The Whitwell fire-brick hot-blast stove, also an English invention, was first used in this country at Rising Fawn furnace, in Dade county, Georgia, on June 18, 1875. Its next application was at Cedar Point furnace, at Port Henry, in Essex county, New York, on August 12, 1875. The stoves at Cedar Point furnace were, however, built before those at Rising Fawn furnace. The first application of this stove in Pennsylvania was made as late as February, 1877, at Dunbar furnace, in Fayette county. The Rising Fawn and Dunbar furnaces used coke as fuel, while Cedar Point furnace used anthracite. The first set of Siemens-Cowper-Cochrane fire-brick hot-blast stoves erected in this country was erected at one of the Crown Point furnaces, in Essex county, New York, in 1877; but the first set of these stoves erected in America was erected at Londonderry, in Nova Scotia, by the Steel Company of Canada

Limited, in 1876. The Siemens-Cowper-Cochrane stove is also an English invention. Both it and the Whitwell stove embody the regenerative principle in storing heat. The introduction of these stoves has greatly promoted the economic management of American blast furnaces and increased their yield, supplementing and in all respects rivaling the good work inaugurated when the Player stove was introduced.

In the twenty years between 1840 and 1860 the plan of conveying the escaping gases from the top of the blast furnace to the boilers and hot-blast ovens, or stoves, gradually came into general use as a substitute for independent fires or for the use of the flame at the tunnel-head. Its introduction was greatly promoted between 1842 and 1850 by the efforts of Mr. C. E. Detmold, a German engineer, then residing at New York, but recently residing at Paris, who had taken out a patent in this country as the assignee of Achilles Christian Wilhelm von Faber du Faur, the superintendent of the government iron works at Wasseralfingen, in Wurtemberg, Germany, who had invented a method of utilizing furnace gases in heating the blast. The first practical experiments with this invention in utilizing furnace gases in the production of heat were made in 1836 and 1837 at Wasseralfingen.

Achilles Christian Wilhelm von Faber du Faur was born on December 2, 1786. He studied at Freiberg in 1808; was first assistant superintendent of the government iron works at Kœnigsbronn in 1810, and afterwards was superintendent for thirty-two years of the government iron works at Wasseralfingen. In 1843 he became a member of the Mining Council (*Bergrath*) at Stuttgart, but owing to ill health he was compelled to retire from active service in 1845. He died on March 22, 1855.

David Thomas, of Catasauqua, Pennsylvania, was the first person in the United States to fully realize the value of powerful blowing engines in the working of blast furnaces. About 1852 he introduced engines at his furnaces at Catasauqua which increased the pressure to double that which was then customary in England. The results were surprising. But many years elapsed before Mr. Thomas's example was generally followed in this country. Within the past few years, however, our superior blast-furnace practice has been mainly

due to the use of blowing engines of great power. English ironmasters have only recently commenced to imitate the best American practice in this respect.

At the Siberian rolling mill of Rogers & Burchfield, at Leechburg, in Armstrong county, Pennsylvania, natural gas, taken from a well 1,200 feet deep, was first used as a fuel in the manufacture of iron. In the fall of 1874 it was announced that during the preceding six months the gas had furnished all the fuel required for puddling, heating, and making steam, not one bushel of coal having been used. Between 1874 and 1881 natural gas for puddling was successfully used at the same rolling mill at Leechburg; at the works of Spang, Chalfant & Co., and Graff, Bennett & Co., in Allegheny county, Pennsylvania; and at the rolling mill of the Kittanning Iron Company, at Kittanning, Pennsylvania. In each instance the gas used at these works was obtained from wells that were sunk for oil but were found to produce only gas. Since 1881, and particularly since 1883, natural gas has been introduced into many iron and steel works in Western Pennsylvania. The method employed in using the gas at Kittanning in the summer of 1881 has been described as follows:

The gas is brought from a well some three miles distant, in four-inch casing, and at the mill is distributed amongst eighteen boiling furnaces. The furnaces are the same as those in which coal is used. The gas enters the rear of the furnace in three small pipes, shaped at the end like a nozzle. There being quite a pressure, the gas enters with considerable force, and by means of dampers to regulate the draft an intense and uniform heat is obtained. After a heat the furnace is cooled and prepared for the next heat in the same manner as with coal. When the metal is in place the gas is turned on, and the operation of puddling is the same, with the exception that it is somewhat slower. Only one-half of the well's production of gas is in fact consumed by the eighteen furnaces here described. The puddlers like the gas very much, as it reduces their labor to some extent, and they say they can make better weight than with coal. The furnaces being free from sulphur a better quality of iron is produced, and it brings a slightly advanced price in the market. These furnaces have been running all the time for some months past, and have used nothing but gas for fuel, which has proved satisfactory in every respect, and is found to be much cheaper than coal.

We have previously recorded the erection in 1817, at Plumsock, in Fayette county, Pennsylvania, of the first rolling mill in the United States for the production of bar iron.

The first puddling in this country was also done at this rolling mill in the same year. It may seem strange to many of the present generation, who witness the number and magnitude of our iron and steel establishments, that such important processes as the puddling of pig iron and the rolling of bar iron should not have been introduced into the United States until sixty-seven years ago, but we have been unable to locate their introduction at an earlier period. Careful inquiry fails to discover the existence in the United States of any rolling mill to puddle pig iron and roll bar iron prior to the enterprise at Plumsock in 1817. Ralph Crooker, recently of the Bay State iron works, at Boston, the oldest rolling-mill superintendent in the United States, writes us that the first bar iron rolled in New England was rolled at the Boston iron works, on the mill-dam in Boston, in 1825, and that the first puddling done in New England was at Boston, on the mill-dam, by Lyman, Ralston & Co., in 1835.

Before the use of bituminous and anthracite coal became general in this country wood as it comes from the forest was sometimes used to puddle pig iron, as it is now used at some places in Sweden, and it was also used in the heating furnaces of rolling mills. From 1821 to 1825 the Fall River rolling mill, in Massachusetts, used wood in heating iron for nail plates. In 1848 pig iron was puddled with wood at Adirondack, in Essex county, New York. Prior to 1850 puddling with wood was done at Horatio Ames's works at Falls Village, in Connecticut. In 1858 the Hurricane rolling mill and nail works, on Pacolet river, 43 miles west of Yorkville, in South Carolina, used dry pine wood in its puddling and heating furnaces; and in the preceding year the Cherokee Ford rolling mill, on Broad river, in Union county, in the same State, used "splint" wood for the same purpose.

The beginning of the regular manufacture of Connellsville coke, which is especially celebrated for its excellence as a fuel for blast furnaces, dates from the summer of 1841, when Provance McCormick and James Campbell made an agreement with John Taylor by which he was to erect two ovens for making coke on his farm lying on the Youghiogheny river, near Sedgwick Station, a few miles below Connellsville, Pennsylvania. The ovens were built of the bee-hive pattern. Af-

ter repeated failures a fair quality of coke was produced in the winter of 1841–'42. By the spring of 1842 enough coke had been made to load two coal boats, each of which was 90 feet long. These boats were built by McCormick and Campbell, who were carpenters. Both boats were taken by William Turner, pilot, down the Youghiogheny, the Monongahela, and the Ohio to Cincinnati, where purchasers were obtained for the coke after some difficulty. Others embarked in the business of manufacturing coke in 1842, and were more successful. About 1844 improved ovens were introduced by Colonel A. M. Hill, whose energy and success gave much impetus to the coke business. In 1855 there were only 26 coke ovens at work on the Monongahela river, and in all Western Pennsylvania there were probably less than a hundred; now their number may be counted by thousands, most of which are built upon improved models. To-day Connellsville coke is extensively used in the blast furnaces of many States, its use for this purpose extending to the Mississippi valley. Fully one-third of the annual production of pig iron in this country is now made with this fuel. Its use as a furnace fuel properly dates from 1860, when it was first used at Pittsburgh in a furnace owned by Graff, Bennett & Co., and known as Clinton furnace. This was the first continuous and successful use of Connellsville coke in a blast furnace. This coke is free from sulphur, but contains more ash than the celebrated Durham coke of England. One hundred pounds of Connellsville coal will make 62½ pounds of coke.

The Phœnix wrought-iron column, which is now in general use in this country and in Europe in the construction of wrought-iron bridges, viaducts, depots, warehouses, and other structures, is the invention of the late Samuel J. Reeves, of Philadelphia, a member of the Phœnix Iron Company, of Phœnixville, Pennsylvania. The invention was patented on June 17, 1862.

Mr. Reeves was born at Bridgeton, New Jersey, on March 4, 1818, and died at Phœnixville on December 15, 1878, aged over 60 years. For many years previous to his death he had been president of the American Iron and Steel Association and of the Phœnix Iron Company.

Down to 1846, when John Griffen built a rolling mill at

Norristown, Pennsylvania, for Moore & Hooven, steam boilers had never been put over puddling and heating furnaces in any country. In this mill all the steam that was needed for driving the mill was generated in boilers over the puddling and heating furnaces, no auxiliary boilers being used, thus greatly economizing fuel. Mr. Griffen met with much opposition from observers while engaged in constructing the mill upon this plan, and many predictions were made that the new arrangement would be a failure. It was a great innovation on the practice then prevailing, but it was a complete success, and its general adoption has effected a saving in fuel to the iron manufacturers in this country of many millions of dollars.

John Griffen was born at Mamaroneck, in Westchester county, New York, on February 16, 1812, and died at Phœnixville, Pennsylvania, on January 14, 1884, aged nearly 72 years. He was for many years the general superintendent of the Phœnix iron works, at Phœnixville, and was the inventor of the Griffen gun.

Mr. Joseph C. Kent, superintendent of the blast furnaces of the Andover Iron Company, at Phillipsburg, New Jersey, writes to us concerning two noteworthy achievements at one of these furnaces many years ago. These furnaces were then known as the Cooper furnaces. In one week in 1850 there were produced in No. 1 furnace 251½ tons of pig iron, and in one week in 1858 there were produced in the same furnace 319 tons of pig iron. The fuel used in both instances was anthracite coal; the engines used were not large, being capable of blowing only from 7,000 to 8,000 cubic feet of air per minute, under a pressure of from 3 to 3½ pounds per square inch. The blast was heated in ordinary syphon pipe ovens to 500° Fahrenheit. The size of this furnace was 20 feet by 55 feet. The above products were respectively the largest that had been produced in the world down to the dates mentioned.

Mr. J. King McLanahan informs us that in 1853 Frankstown charcoal furnace, in Blair county, Pennsylvania, was changed to a coke furnace, the first in that county, and made No. 1 foundry pig iron from Frankstown block fossil ore. The furnace buildings were burned down in 1855, and Mr. McLanahan, the manager, "banked up on a full burden."

After a delay of exactly fourteen days the blast was again turned on, and in twelve hours the furnace was working as well as before the accident occurred. This was the first attempt that was made in this country to "bank up" a coke furnace for so long a time.

Isabella furnace No. 1, located at Etna, near Pittsburgh, closed early in 1884 a three-years' blast which produced remarkable results. Its product was as follows, in tons of 2,268 pounds. Pig iron made in 1881, 324 days, 37,437½ tons; in 1882, 365 days, 59,032 tons; in 1883, 365 days, 66,408½ tons; in 1884, 19 days, 3,927 tons: total in three years, less 22 days, 166,805 tons, or an average of 1,090 tons per week. The unexampled good work of this furnace was obtained notwithstanding a serious interruption caused by a freshet in the Allegheny river, and notwithstanding other drawbacks. The furnace is 20 feet in diameter at the bosh, 75 feet high, 11 feet in diameter at the hearth, contains a 14-foot stock line, and has seven 7-inch tuyeres. It is equipped with three Whitwell stoves of the largest size, and three engines having 7-foot blowing cylinders with a 4-foot stroke.

In 1856 two shafts were made at the Reading steam forge, at Reading, Pennsylvania, for the steamship *Adriatic*. Each shaft when finished was 35½ feet in length, 27½ inches in diameter, and weighed 78,500 pounds, or 35 tons. Two cranks of 12-foot stroke were made at the same time, each weighing when finished 18,800 pounds, or 8.39 tons. The forge was then the largest and most complete in this country. It contained four hammers, of ½, ¾, 1½, and 7 tons' weight respectively. An account of the forging of the shafts says: "The shafts of the *Adriatic* were forged in twelve working days each. They were commenced on what is called a 'porter bar,' forming a tapering handle, to which are attached 'levers,' or cranks, to turn the shaft in its slings while under the hammer. The porter bar was first heated, and then flattened at its thick end to receive a 'pile' of bloom bars each about 250 pounds' weight, all of which were welded solid with each other and the bar, thus forming the commencement of the shaft itself. The end of the shaft thus commenced was again heated to receive another pile of bars as already described, and the same process thus repeated until the shaft was made the

length required. When the shaft becomes sufficiently long the 'porter bar' is cut off, and the turning cranks attached to the shaft itself."

On the 6th of September, 1881, Park, Brother & Co., of Pittsburgh, put in operation for the first time their 17-ton steam hammer, which is the largest in the United States. It will work steel ingots two feet square. The hammer itself was built by William B. Bement & Son, of Philadelphia. The anvil, which is the heaviest iron casting ever made in this country, weighing 160 tons, was cast a few feet from its place with five cupolas, under the direction of Park, Brother & Co., on October 5, 1880. It is 11 feet high, and measures 8 by 10 feet at the base, and 4 by 6 feet at the top. The hammer and its fittings occupy a ground space 26 feet long by 13 feet wide. Its height from the ground is 32 feet. The framing is of wrought-iron plates from $\frac{7}{8}$ of an inch to $1\frac{1}{8}$ inches thick, bolted and riveted and strengthened with angle irons. The weight of the cast-iron cylinder is about 11 tons, the bore is 40 inches, and the stroke 9 feet. The piston, rod, ram, and die weigh about 17 tons. When the steam is admitted on top of the piston it will produce an additional force or weight of about 50 tons, making 67 tons' pressure in all when the ram or hammer is stationary. The whole cost of the hammer, anvil, and fittings, ready for operation, is estimated at $52,000. In August, 1883, Park, Brother & Co. forged with this hammer a steel steamboat shaft $32\frac{1}{2}$ feet long and weighing 30,240 pounds, or $13\frac{1}{2}$ tons. The ingots used, which were of open-hearth steel, weighed 32,000 pounds. The shaft was hexagonal in the centre, tapering at each end to a circular shape.

There are still in existence in this country several old-fashioned slitting mills, which are used spasmodically in the conversion of iron into nail rods. There is a slitting mill at the Cambridge rolling mills, near Boston; at the Norway steel and iron works, at South Boston; at the Eagle iron works, at Roland, Centre county, Pennsylvania; and at the Oxford iron and steel works, at Frankford, in Philadelphia. The demand for slit nail rods grows less, however, every year, and it is probable that even the occasional use of the slitting mills above mentioned will soon be a thing of the past.

The excellent wearing qualities of American iron rails have been conclusively demonstrated by long experience. This was illustrated at the Philadelphia Exhibition in 1876, when the Cambria Iron Company exhibited an iron rail that had been in use nineteen years, three rails that had been in use eleven years, and five rails that had been in use ten years, all under severe wear. The same company also exhibited two iron rails which bridged a gap, 12 feet wide and 12 feet deep, that had been washed out under the track of a western railroad, and which carried safely over the gap an engine weighing 57,400 pounds and a train of seven cars. The American Iron and Steel Association collected a mass of statistics in 1879 from American railroad companies relative to the wear of domestic and foreign steel rails, and the general conclusion was derived that American steel rails are superior to English steel rails, while the testimony of the Pennsylvania Railroad Company demonstrated that the American steel rails which had been laid in its tracks were wearing almost twice as well as the foreign steel rails it was also using.

CHAPTER XLI.

THE EARLY HISTORY OF IRON RAILS IN THE UNITED STATES.

THE influence of railroads upon the development of the iron and steel industries of the United States has been so great that we may appropriately present in this chapter some of the leading facts connected with the laying of the first rails upon American railroads and with the manufacture of the first American rails.

The first railroads in the United States were built to haul gravel, stone, anthracite coal, and other heavy materials, and were all short, the longest not exceeding a few miles in length. Strictly speaking they were tramroads and not railroads. One of these was built on Beacon Hill, in Boston, by Silas Whitney, in 1807; another by Thomas Leiper, in Delaware county, Pennsylvania, in 1809; and another at Bear Creek furnace, in Armstrong county, Pennsylvania, in 1818. The tracks of these roads were composed of wooden rails. Other short tramroads were built in various places early in this century, and were similarly constructed. In George W. Smith's notes on Wood's *Treatise on Railroads* (1832) it is stated that in 1816 the first railroad in the United States on which self-acting inclined planes were used was "built by Mr. Boggs," on the Kiskiminetas river, in Western Pennsylvania. This road was used to convey bituminous coal to Andrew Boggs's salt works.

Prior to 1809 Oliver Evans, of Philadelphia, to whom as much as to any other person the honor of inventing the locomotive is due, urged in repeated addresses to the public the construction of a passenger railroad from Philadelphia to New York, and in that year he unsuccessfully attempted to form a company for this purpose. In 1812 Colonel John Stevens, of Hoboken, New Jersey, published a pamphlet, recommending the building of a passenger railroad from Albany to Lake Erie, but his suggestions were not heeded. In the *History of Morris County*, New Jersey, Mr. Halsey says: "As

early as 1815 a railroad, either of wood or iron, was chartered from the Delaware river near Trenton to the Raritan near New Brunswick. This was the first railroad chartered in America. It was never built."

On the 7th of April, 1823, the New York legislature chartered the Delaware and Hudson Canal Company to construct a canal and railroad from the coal fields of Pennsylvania to the Hudson river at Rondout, in New York. The canal was completed in 1828, but the railroad was not completed until 1829. The latter was 16 miles long, and extended from Honesdale to Carbondale. It was built to carry coal.

In 1826 the Quincy Railroad, in Massachusetts, 4 miles long, including branches, was built by Gridley Bryant and Colonel T. H. Perkins, to haul granite blocks from the Quincy quarries to the port of Neponset. The rails of this road were made of wood, but strapped with iron plates 3 inches wide and ¼ of an inch thick. In 1827 the Mauch Chunk Railroad, in Carbon county, Pennsylvania, 9 miles long, with 4 miles of sidings, was built to connect the coal mines of the Lehigh Coal and Navigation Company with the Lehigh river. Its rails were also made of wood and strapped with iron. Gordon, in his *Gazetteer of the State of Pennsylvania*, says of this road: "The railway is of timber, about 20 feet long, 4 inches by 5, and set in cross-pieces made of cloven trees placed 3½ feet from each other, and secured by wedges. The rail is shod on the upper and inner edge with a flat bar of iron 2¼ inches wide and ⅝ of an inch thick." Solomon W. Roberts says of the Mauch Chunk road: "It was laid mostly on the turnpike, and was a wooden track, with a gauge of 3 feet 7 inches, and the wooden rails were strapped with common merchant bar iron, the flat bars being about 1½ inches wide and ⅜ of an inch thick. The holes for the spikes were drilled by hand. Although a great deal of bar iron, of somewhat varying sizes, was bought for the purpose, the supply fell short, and, to prevent delay in opening the road, strips of hard wood were spiked down in place of iron on about a mile and a half or two miles of the road, as a temporary expedient."

Mr. Roberts relates that the Lehigh Coal and Navigation Company made a short section of experimental railroad at its foundry in Mauch Chunk in the summer of 1826. "The idea

then was to make a road with rails and chairs of cast iron, like those in use at the coal mines in the North of England. After casting a good many rails, each about 4 feet long, the plan was given up on account of its being too expensive."

In 1826 the New York legislature granted a charter for the construction of the Mohawk and Hudson Railroad, for the carriage of freight and passengers from Albany to Schenectady, a distance of 17 miles. Work on this road, however, was not commenced until August, 1830. It was opened for travel on September 12, 1831.

On February 28, 1827, the Maryland legislature granted a charter for the construction of the Baltimore and Ohio Railroad, which was the first railroad in the United States that was opened for the conveyance of passengers. Its construction was commenced on July 4, 1828, the venerable Charles Carroll, of Carrollton, laying the corner-stone. In 1829 the track was finished to Vinegar Hill, a distance of about 7 miles, and "cars were put upon it for the accommodation of the officers and to gratify the curious by a ride." Mr. Poor, in his *Manual of the Railroads of the United States*, says that the road was opened for travel from Baltimore to Ellicott's Mills, a distance of 13 miles, on May 24, 1830. The Washington branch was opened from Relay to Bladensburg on July 20, 1834, and to Washington City on August 25, 1834.

The next passenger railroad that was undertaken in the United States was the Charleston and Hamburg Railroad, in South Carolina, which was chartered on December 19, 1827. Six miles of the road were completed in 1829, but they were not opened to the public until December 6, 1830, when a locomotive was placed on the track. The road was completed in September, 1833, a distance of 135 miles. At that time it was the longest continuous line of railroad in the world. The Columbia branch was opened on November 1, 1840, and the Camden branch on June 26, 1848.—We need not further note the beginning of early American railroads.

The rails used on the Charleston and Hamburg and the Mohawk and Hudson railroads were made of wood, with flat bar iron nailed upon their upper surface. A writer in Brown's *History of the First Locomotives in America* says that the track of the Baltimore and Ohio Railroad consisted of cedar cross-

pieces, and of string-pieces of yellow pine "from 12 to 24 feet long and 6 inches square, and slightly beveled on the top of the upper side for the flange of the wheels, which at that time was on the outside. On these string-pieces iron rails were placed and securely nailed down with wrought-iron nails, 4 inches long. After several miles of this description of road had been made long granite slabs were substituted for the cedar cross-pieces and the yellow-pine stringers. Beyond Vinegar Hill these huge blocks of this solid material could be seen deposited along the track, and gangs of workmen engaged in the various operations of dressing, drilling, laying, and affixing the iron." Brown says that "iron strips were laid, for miles and miles, on stone curbs on the Baltimore and Ohio Railroad." Appleton's *American Cyclopædia* says that the iron used was ½ and ⅝ of an inch thick, and from 2½ to 4½ inches wide, and that the heads of the spikes which fastened it were countersunk in the iron.

Before the Baltimore and Ohio Railroad had been finished to Point of Rocks in 1832 "wrought-iron rails of the English mode," says Brown, had been laid down on a part of the line. It had been found in practice that the strap rail would become loosened from the wooden or stone stringer, and that the ends of it, called "snakes' heads," were liable to be forced by the wheels through the bottom of the cars, to the jeopardy of the passengers. The English rails obviated this inconvenience and risk. Some account of these rails is here necessary.

About the time when the Baltimore and Ohio Railroad was finished to Point of Rocks various patterns of heavy rolled iron rails were in use in England. The first of these to be used was the fish-bellied rail, which was invented by John Birkinshaw, of the Bedlington iron works, and patented in October, 1820, and which fitted into a cast-iron chair. A thin wedge, or key, of wrought iron was driven between the inside of the chair and the rail, to keep the latter firmly in its place, and the operation of "driving keys" had to be repeated almost every day.

The Birkinshaw rail was used on the Stockton and Darlington Railroad, in England, which was opened in September, 1825, and was the first railroad in the world that was opened for general freight traffic and passenger travel. The greater

part of the Stockton and Darlington road, which was 37 miles long, was laid with rolled rails of this pattern, weighing 28 pounds to the yard; a small part of the line was laid with fish-bellied cast-iron rails. The Liverpool and Manchester Railroad, which was opened in September, 1830, and which was the second railroad built in England for general business in the transportation of freight and passengers, used rails which were also of the Birkinshaw pattern. "The rails used were made of forged iron, in lengths of 15 feet each, and weighed 175 pounds each. At the distance of every 3 feet the rail rests on blocks of stone. Into each block two holes, 6 inches deep and 1 inch in diameter, are drilled; into these are driven oak plugs, and the cast-iron chairs into which the rails are fitted are spiked down to the plugs, forming a structure of great solidity." This road was about 31 miles long.

The Clarence rail was an English improvement on the Birkinshaw rail; it also rested in a chair, but it did not have the fish-belly, its upper and lower surfaces being parallel to each other. Rails of the Clarence pattern were used upon the Allegheny Portage Railroad in Pennsylvania, which was finished in 1833, and many of the stone blocks on which they were laid can yet be seen in its abandoned bed. The Columbia and Philadelphia Railroad was opened on the 16th of April, 1834. On a small part of this road flat rails were laid, either directly on granite blocks or on wooden string-pieces, but on the greater part of it Clarence rails were laid on stone blocks. On the Boston and Lowell Railroad, which was chartered in June, 1830, and completed in 1835, stone cross-ties were at first laid, some of which were in use as late as 1852. On one track of this road the fish-bellied Birkinshaw rail was used, and on the other track the H rail was laid. This rail, which rested in a chair, had a web, or flange, similar to that of the modern T rail. The H rail was laid upon the Washington branch of the Baltimore and Ohio Railroad. It was 15 feet in length, weighed 40 pounds to the yard, and was laid on string-pieces of wood.—Wooden cross-ties have been substituted for stone blocks on all American railroads.

The flat rail which was first used on American railroads continued in use for many years, notwithstanding the difficulty experienced in keeping it in its place. At first the holes

for the spikes were drilled by hand. The flat rails that were afterwards made were indented, or countersunk, at regular distances in their passage through the rolls. The centre of the countersunk surface was then punched through for the admission of the spike. As late as 1837, when the Erie and Kalamazoo Railroad was in course of construction from Toledo to Adrian, it was proposed to put down wooden rails, of oak studding 4 inches square, and to draw the cars by horses. But wiser counsels prevailed, and by great exertions sufficient funds were obtained to enable the management to iron the road with flat rails $\frac{5}{8}$ of an inch thick. Mr. Poor says: "It was not until 1850 that the longitudinal sill and the flat rail were entirely removed from the Utica and Schenectady Railroad, the most important link in the New York Central line." Flat rails were in use on many other railroads in this country after 1850, and may yet be seen on some Southern railroads. They are also in use on street railroads and on most tramroads.

The following extract from a New York newspaper, dated May 30, 1844, shows the risk to which travelers were subjected who journeyed on railroads the tracks of which were laid with flat rails.

> RAILROAD CASUALTY.—The cars on the railroad a short distance east of Rome, New York, came in contact with a "snake head" on Saturday morning which threw several of the passenger cars and the mail car off the track. The crush was tremendous, and the cars were torn to splinters, though happily no lives were lost. Mr. Peter Van Wie was badly bruised, and some others slightly injured.

Cast-iron rails were made in this country in small quantities during the early years of our railroad history, notwithstanding the unfavorable experiment in their use at Mauch Chunk which is noted by Mr. Roberts. Johnson, in his *Notes on the Use of Anthracite*, published in 1841, records a series of tests made in that year with rails for mine roads, cast in a foundry from pig iron made at the Pottsville furnace of William Lyman. These rails were 6 feet long and were of various weights. It is particularly stated of one rail which was tested that it was "intended to sustain locomotives." The rails were bulbous at both the top and bottom, like the double-headed, or H, rail now used in England, but they had at each end, for about 3 inches along the base, flanges for securing

them to the cross-ties, which caused an end view of them to resemble that of a modern T rail.

Many years elapsed after the first railroad was built in this country before any other than flat iron rails were made in American rolling mills. Among the proposals to furnish heavy rails for the Columbia and Philadelphia Railroad, received in May, 1831, there were none for American rails, and the whole quantity was purchased in England. It is necessary to explain here that previous to the passage of the tariff act of 1842 rails were admitted into this country virtually free of duty. On the passage of that act American capitalists began to think about making heavy rails.

Early in 1844 there were still no facilities in this country for the manufacture of heavy iron rails to supply the wants of the 4,185 miles of American railroad which existed at the beginning of that year, and of a few hundred additional miles which were then projected. In a memorial which was laid before Congress in that year the Hon. John Tucker, the president of the Philadelphia and Reading Railroad Company, under date of May 4, 1844, made the following declaration.

Immediately on the line of the road are rich mines of iron ore. Last fall and winter it was generally known in that section of the State through which the road passes, as well as on other portions of it, that this company intended to lay a second track, and that about 8,300 tons of railroad iron was wanted. Public proposals were issued for all the materials required, except the iron. The iron was not included in these proposals for the simple reason that I knew that it could not be furnished in this country, but I had interviews with several of the largest ironmasters, and freely expressed my desire to contract for American railroad iron, provided it could be furnished at the time it was wanted. I received no proposition to deliver the rolled bars. I inclose a copy of a letter from one of the largest ironmongers in the State, offering cast-iron rails, which, I presume you are aware, have not answered any good purpose. I also inclose a copy of my answer, to which I have not received a reply. I unhesitatingly express my conviction that the railroad iron needed by this company could not have been obtained in this country, at the time they required it, at any price; and I am equally confident that there are no parties ready to contract to deliver such iron for a long time to come. This company was therefore compelled to import their iron.

The following is the correspondence referred to above concerning the proposition to make cast-iron rails for the Philadelphia and Reading Railroad Company.

PHILADELPHIA, November 7, 1843.

MR. TUCKER. DEAR SIR: Since my conversation with you, in relation to substituting cast-iron rails for your new track of rails which you contemplate laying soon, I have concluded to propose to you that I should cast eighteen bar-rails 15 feet long from the model in the Franklin Institute, as a sample of the strength and durability of rails made from cast iron. The price to be $30 per ton cash upon delivering at Broad street.

With respect, yours, CLEMENT B. GRUBB.

Direct Lancaster, Pennsylvania.

OFFICE OF THE PHILADELPHIA AND READING RAILROAD COMPANY,
PHILADELPHIA, November —, 1843.

CLEMENT B. GRUBB, Esq., *Lancaster*. DEAR SIR: I duly received your communication of the 7th instant. This company is not disposed to make any experiment with the cast-iron rails on their own account. But if you choose to send the eighteen bars they shall be laid on the road; and if, after a trial of six months, they are found to answer a good purpose the company will pay you $30 per ton for the rails. If they are not suitable for the road they will then be delivered to you, the company merely incurring the expense of laying down and taking up the rails.

Your obedient servant, JOHN TUCKER, *President*.

No reply to this letter was received. The 8,300 tons of rails which were wanted by Mr. Tucker, and which he was compelled to buy in England, were of the H pattern, then very popular. The rails weighed 60 pounds to the yard, and cost £5 10s. per ton in England.

In a letter dated May 22, 1844, which formed a part of the above-mentioned memorial to Congress, Joseph E. Bloomfield made the following statement.

There is no doubt of the fact that there are no establishments for the manufacture of railroad iron in Pennsylvania prepared to produce a moiety of the iron required for the railways actually commenced. Mr. Oakley, of Brooklyn, made a statement, that at the time was combated and denied, that he could furnish from one set of works 10,000 tons of railroad iron per annum. This is so palpably incorrect that it needs no refutation. There is no iron establishment of this kind in this country.

On the 24th of April, 1844, the Hon. Edward Joy Morris, of Pennsylvania, declared that "not a ton of T rail had yet been made in this country." He might have included all other patterns except strap rails.

The manufacture of heavy iron rails in this country was commenced in 1844 at the Mount Savage rolling mill, in Alleghany county, Maryland, which was erected in 1843 espe-

cially to roll these rails. The first rail rolled at this rolling mill, and in honor of which the Franklin Institute of Philadelphia awarded a silver medal in October, 1844, was a U rail, known in Wales as the Evans patent, of the Dowlais iron works, at Merthyr Tydvil. It was intended to be laid on a wooden longitudinal sill, and to be fastened to it by an iron wedge, keying under the sill, thus dispensing with outside fastenings. This rail weighed 42 pounds to the yard. About 500 tons of rails of this pattern were laid in 1844 on a part of the road then being built between Mount Savage and Cumberland, a distance of nine miles. Soon afterwards rails weighing 52 pounds to the yard were rolled at the Mount Savage rolling mill for the road leading from Fall River to Boston. The foregoing information was obtained by us from Henry Thomas Weld, of Mount Savage, who is still living. Mr. Stephen S. Lee, of the old firm of Manning & Lee, of Baltimore, says that in 1845 and 1846 the firm sold to Boston purchasers T rails which were made at Mount Savage. The Mount Savage rolling mill was dismantled in 1875, after having been abandoned for many years.

The Montour rolling mill, at Danville, Pennsylvania, was built in 1845 expressly to roll rails, and here were rolled in October of that year the first T rails made in the United States. The first T-rail rolls made in this country were made for the Montour Iron Company by Haywood & Snyder, proprietors of the Colliery iron works at Pottsville, the work being done at their branch establishment at Danville. The Boston iron works were started in January, 1824, to manufacture cut nails, hoops, and tack plates, but they subsequently rolled rails, and on the 6th of May, 1846, they rolled the first T rails in Massachusetts, Ralph Crooker being superintendent. In 1845 the rolling mill of Cooper & Hewitt was built at Trenton, New Jersey, to roll heavy rails, and on the 19th of June, 1846, their first T rail was rolled. About the 1st of September, 1846, the New England Iron Company, at Providence, Rhode Island, commenced to roll T rails. The first lot of these rails rolled by the company was delivered to the Providence and Worcester Railroad on September 11, 1846. T rails were rolled in November, 1846, at Phœnixville, Pennsylvania; in the fall of the same year at the Great Western

iron works at Brady's Bend, Pennsylvania, and at the Lackawanna iron works at Scranton, Pennsylvania; early in 1847 at the Bay State rolling mill, in Massachusetts, then owned by the Massachusetts Iron Company; in January, 1848, at the Rough-and-Ready rolling mill at Danville, Pennsylvania; and in the same year at Safe Harbor, Pennsylvania. On May 10, 1848, Manning & Lee, the agents of the Avalon iron works, near Baltimore, Maryland, contracted to manufacture at these works for the Baltimore and Ohio Railroad Company 400 tons of U rails, to weigh 51 pounds to the yard and to be from 19 to 21 feet in length, the price to be $65 per gross ton, delivered at Baltimore. These rails were made in 1848. All of the T rails made at the mills above mentioned were rolled with a base or flange similar to that of the present T rail. Some of them did not differ greatly from the H rail, and when laid rested, like it, in a chair. Indeed the H rail was sometimes called the T rail. A few other mills rolled heavy rails before 1850, but at the beginning of that year, owing to the severity of foreign competition under the tariff of 1846, only two out of fifteen rail mills in the country were in operation.

From *A History of the Growth of the Steam Engine*, by Robert H. Thurston, we learn that the T rail which is now in general use is an American invention. Professor Thurston says: "Robert L. Stevens, the president and engineer of the Camden and Amboy Railroad, and a distinguished son of Colonel John Stevens, of Hoboken, was engaged, at the time of the opening of the Liverpool and Manchester Railroad, in the construction of the Camden and Amboy Railroad. It was here that the first of the now standard form of T rail was laid down. It was of malleable iron. It was designed by Mr. Stevens, and is known in the United States as the 'Stevens' rail. In Europe, where it was introduced some years afterwards, it is sometimes called the 'Vignoles' rail." This name is derived from Charles B. Vignoles, an English railroad engineer, who visited the United States about 1820. Professor Thurston adds that a part of the track of the Camden and Amboy Railroad at Bordentown was laid down and opened for business in 1831. T rails were laid on the whole line, which crossed the State of New Jersey.

Through the courtesy of Professor Thurston we have been

furnished with a *fac-simile* of the circular issued by Mr. Stevens in 1830, inviting proposals from British manufacturers for supplying the Camden and Amboy Railroad with T rails. It will be found in our report on iron and steel accompanying the tenth census (1880) of the United States. In this circular Mr. Stevens specified that the rail which he desired to have rolled should have a base like the T rail of the present day, the rail to be 12 or 16 feet long, and to be laid on cross-ties, but that it should have "projections on the lower flange at every two feet," where it would rest on the ties.

The sides of the rails rolled for Mr. Stevens were made straight, and without "the projections on the lower flange at every two feet" which were specified in his circular. These projections were intended to serve the purposes of the chairs then in use, by giving a broad base to the rail at its connection with the cross-ties. They were, of course, not necessary, but that the rails were rolled without them was clearly not in accordance with Mr. Stevens's original design. However, he may truthfully be said to have invented the T rail. It was the first heavy rail manufactured which dispensed with chairs.

Mr. Francis B. Stevens, of Hoboken, New Jersey, a nephew of Robert L. Stevens, has supplied us in the following letter with additional information concerning the history of the T rail. His letter is valuable.

HOBOKEN, NEW JERSEY, May 31, 1881.

DEAR SIR: In answer to your letter of the 27th instant I will say that I have always believed that Robert L. Stevens was the inventor of what is called the T rail, and also of the method of fastening it by spikes, and I have never known his right to the invention questioned.

The rail of the Liverpool and Manchester Railroad, on its opening, in September, 1830, was of wrought iron, divided into fish-bellied sections, each section being supported by a cast-iron chair, to which it was secured by a wooden wedge. This form was derived from the old cast-iron fish-bellied tram rail, cast in single sections, each about 36 inches long. This wrought-iron rail was afterwards improved by making its bottom straight uniformly throughout its length.

Mr. Stevens's invention consisted in adding the broad flange on the bottom, with a base sufficient to carry the load, and shaped so that it could be secured to the wood below it by spikes with hooked heads; thus dispensing with the cast-iron chair, and making the rail and its fastening such as it now is in common use. In the year 1836 and frequently afterwards he spoke to me about his invention of this rail, and told me that in London, after unsuccessful applications elsewhere in England, shortly after the open-

ing of the Liverpool and Manchester Railroad, he had applied to Mr. Guest, a member of Parliament, who had large rolling mills in Wales, to take a contract to make his rail for the Camden and Amboy Railroad, of which he was the chief engineer; that Mr. Guest wished to take the contract, but considered that it would be impracticable to roll the rail straight; that, finally, Mr. Guest agreed to go to Wales with him and make a trial; that great difficulty was at first experienced, as the rails coming from the rolls curled like snakes, and distorted in every imaginable way; that, by perseverance, the rail was finally successfully rolled; and that Mr. Guest took the contract. The Camden and Amboy Railroad, laid with this rail, was opened October 9, 1832, two years after the opening of the Liverpool and Manchester Railroad. Of this I was a witness.

This rail, long known as the old Camden and Amboy rail, differed but little, either in shape or proportions, from the T rail now in common use, but weighed only 36 pounds to the yard. For the next six or eight years after the opening of the Camden and Amboy Railroad this rail was but little used here or abroad, nearly all the roads built in the United States using the flat iron bar, about $2\frac{1}{2}$ inches by $\frac{3}{4}$ inch, nailed to wooden rails, and the English continuing to use the chair and wedge.

My uncle always regretted that he had not patented his invention. He mentioned to me, upwards of forty years ago, that when advised by his friend, Mr. F. B. Ogden, the American consul at Liverpool, who was familiar with the circumstances of his invention, to patent it, he found that it was too late, and that his invention had become public property.

Yours Truly, FRANCIS B. STEVENS.

Smith, in his notes on Wood's *Treatise on Railroads*, thus describes the T rail which was laid on the Camden and Amboy Railroad: "The rails are of rolled iron, 16 feet long, $2\frac{1}{8}$ inches wide on the top, $3\frac{1}{4}$ inches at the bottom, and $3\frac{1}{2}$ deep; the neck half inch thick; the weight is 209 pounds $= 39\frac{3}{16}$ pounds per yard; they are secured by clamps of iron, riveted at the extremity of each bar. The rails are attached to the stone blocks and sleepers by means of nails or pins, at the sides, driven into wooden plugs; chairs are dispensed with."

The first 30-foot rail rolled in this country is claimed to have been rolled at the Cambria iron works, at Johnstown, Pennsylvania, in 1855. These rails were perfectly made, but there being no demand for them they were used in the tracks of the Cambria Iron Company. It is claimed that the first 30-foot rails rolled in the country on order were rolled at the Montour rolling mill, in January, 1859, for the Sunbury and Erie Railroad Company. The first 60-foot, or double-length, rails rolled in this country were rolled by the Edgar Thomson Steel Company, at Bessemer Station, near Pittsburgh, Penn-

sylvania, in the fall of 1875. In 1877 the Lackawanna Iron and Coal Company, at Scranton, Pennsylvania, commenced to roll 60-foot rails. At the Centennial Exhibition at Philadelphia, in 1876, the Edgar Thomson Steel Company exhibited a steel rail which at that time was the longest steel rail that had ever been rolled. It was 120 feet long, and weighed 62 pounds to the yard.

The T rail is not much used in Great Britain. The pattern most in use in that country is the double-headed, or H, rail, which is set in a cast-iron chair. The bridge, or U, rail is in use on the Great Western Railway and on some other British railroads. The Clarence rail is still used on the Great Eastern Railway, and perhaps on some other British railroads. In the United States the T rail is now almost exclusively used. It seems strange that this rail should not have become generally popular in this country until after 1845. We may here mention that the various patterns of rails which superseded the flat rail were long known as edge rails.

The first locomotive to run upon an American railroad was the *Stourbridge Lion*. It was first used on the coal railroad of the Delaware and Hudson Canal Company, at Honesdale, in Wayne county, Pennsylvania, on Saturday, August 8, 1829. The *Stourbridge Lion* was built in England, and it weighed about six tons. Its use was not long continued, because it was too heavy for the superstructure of a large part of the road. The first locomotive built in the United States and used on a railroad was the *Tom Thumb*, which was built by Peter Cooper at Baltimore, and successfully experimented with on the Baltimore and Ohio Railroad in August, 1830. The fuel used for this pioneer American locomotive was anthracite coal. The boiler was tubular, and for want of specially-constructed tubes Mr. Cooper used gun barrels. The locomotive, which was also its own tender, did not weigh a ton. The boiler was about as large as a flour barrel. Strictly speaking it was a working model, but it worked well and led the way to the construction of more powerful locomotives. Mr. Cooper was his own engineer. The first American locomotive that was built for actual service was the *Best Friend of Charleston*, which was built at the West Point foundry, in New

York City, for the Charleston and Hamburg Railroad, and was successfully put in use on that road in December, 1830. On the Mohawk and Hudson Railroad and a few other railroads horse-power was exclusively used for some time after they were opened.

Mr. Brown informs us that "the first charter for what are termed city passenger or horse railroads was obtained in the city of New York and known as the New York and Harlem, and this was the first road of the kind ever constructed, and was opened in 1832. No other road of the kind was completed till 1852, when the Sixth Avenue was opened to the public."

The first elevated city passenger railroad ever built was the Greenwich-street railroad in New York, which was commenced in 1866 and has been in successful operation since 1872. It is now known as the Ninth Avenue Elevated Railway. The next project of this character was the Gilbert elevated railroad, in New York, for the construction of which a charter was granted in 1872. New York City has now several elevated local passenger railroads, but only one other city, Brooklyn, has yet copied her example in building railroads of this class.

The first elevated railroad constructed in this country in connection with a regular freight and passenger railroad was undertaken by the Pennsylvania Railroad Company in 1880 and finished in 1881. It constitutes an extension of the main line of the Pennsylvania Railroad from West Philadelphia to the heart of the old city of Philadelphia, and is over a mile in length.

CHAPTER XLII.

IRON SHIPBUILDING IN THE UNITED STATES.

THE business of building iron ships in this country may properly be said to date from the year 1839, when an iron steamboat was built at Pittsburgh, being the first enterprise of the kind in the United States. This vessel was called the *Valley Forge*. For general navigation purposes it was completely successful. Other iron vessels were subsequently built at Pittsburgh which fully realized the hopes of their builders, among them an iron schooner for ocean service, and an iron steamer, the *Michigan*, for service on the lakes—both built by order of the Government about 1842. In that year Captain John Ericsson, of New York, furnished designs for four freight propeller iron steamers which were built for the Delaware and Raritan Canal, each 96 feet long, 24 feet beam, and 7 feet deep. In 1843 there were also built after his designs the propeller iron steamer *Legaré*, for the revenue service, 150 feet long, 26 feet beam, and 10 feet deep, and four propeller boats for the Erie Canal, each 80 feet long, 14 feet beam, and 6 feet deep. In the same year Captain Ericsson built two steam passenger boats of iron to run on the James River Canal, in Virginia, and about the same time other small iron vessels were built after his designs. In 1846 an iron passenger steamer, the *Iron Witch*, 220 feet long, 27 feet beam, and 13 feet deep, was built at New York, after a design furnished by Captain Ericsson, to run on the Hudson river to Albany. About 1842 the revenue cutter, *McLaine*, an iron vessel, was built at Boston for the Government by Jabez Coney. In 1845 R. B. Forbes, of Boston, built a powerful iron wrecking vessel of 300 tons burden, which was named after himself. Other iron vessels were subsequently built at Boston and elsewhere. The building of iron vessels in this country made but slow progress, however, until after 1860, when the civil war created a demand for them, one of the first to be built being the celebrated *Monitor*, which was designed by John Ericsson and built by him and by Messrs. Winslow & Griswold, of Albany,

New York, the work being done for them at Green Point, Long Island, by Thomas F. Rowland, agent for the Continental iron works. The business of iron shipbuilding has not flourished in this country since the close of the war like other leading branches of American industry, but it has, nevertheless, attained to respectable proportions.

In 1868 five iron steamships were built for ocean service. Since that year over 300 iron vessels have been built, chiefly at shipyards on the Delaware. The tonnage of all the vessels built from 1868 to June 30, 1883, was 335,110 tons. The iron vessels built on the Delaware will favorably compare in every respect with iron vessels built abroad. The only line of passenger steamships plying between this country and Europe which is wholly owned by Americans, and carries the American flag, is the American Steamship Company's line, composed originally of four magnificent iron vessels, the *Pennsylvania, Ohio, Indiana,* and *Illinois*, built at Philadelphia in 1871, 1872, and 1873 of Pennsylvania iron by W. Cramp & Sons, and still running regularly between that port and Liverpool. Their tonnage capacity is 3,100 tons each. Most of the European visitors to the Centennial Exhibition came to Philadelphia and returned to their homes in the vessels of this line. In 1874 John Roach & Son built at Chester, Pennsylvania, for the Pacific Mail Steamship Company, two iron steamships of immense size and superior equipment, which fully equal in all respects the best of British-built iron steamers. These were the *City of Peking* and the *City of Tokio*, twin vessels in every respect. Their registered tonnage is 5,000 tons each. They are still in service.

We have also commenced the construction of vessels of steel. John Roach & Son, of Chester, Pennsylvania, are now engaged in the construction of three cruisers for the United States navy, which are to be built wholly of steel. The same firm launched on the 12th of April, 1884, the dispatch-boat *Dolphin*, also for the navy, and constructed wholly of steel. These are not, however, the first vessels that have been built in the United States with steel instead of iron, but the government statisticians have counted them all as if built of iron. The hulls of the vessels for the navy, above mentioned, are made of open-hearth steel.

From a paper prepared by Francis B. Wheeler, in which he acknowledges his indebtedness for valuable information to a paper by E. P. Dorr, Esq., which was read before the Buffalo Historical Society on the 3d of January, 1874, and from a statement prepared by Captain Ericsson, we compile the following account of the famous *Monitor*. This account we have submitted to the Hon. John F. Winslow, of Poughkeepsie, New York, one of the builders of the vessel, who pronounces it to be correct in every particular.

The *invention* of the *Monitor* belongs to Captain John Ericsson, of New York City, but its *creation* is due to two distinguished ironmasters of the State of New York, namely, the Hon. John F. Winslow and his partner in business, the Hon. John A. Griswold. They were not shipbuilders, had no special facilities for constructing vessels, and knew nothing by experience of the business, and there had never been any iron war ships built in this country; hence, for them to attempt to put afloat any kind of a war vessel was a hazardous experiment. The *Monitor* in all its parts was designed by Mr. Ericsson—hull, turret, steam machinery, anchor-hoister, gun-carriages, etc.; all were built from working drawings made by his own hands, furnishing the rare instance of such a structure in all its details emanating from a single person. But the *Monitor* would not have been built if Messrs. Winslow & Griswold, who were iron manufacturers and men of the highest patriotism, had not pressed upon the Government the adoption of the inventor's daring scheme and afterwards furnished the means to secure the construction of the vessel.

Mr. Winslow carefully examined the plans prepared by Captain Ericsson for the construction of the *Monitor*—plans which had found no favor with the special naval board appointed in 1861, in accordance with an act of Congress, to examine and report upon the subject of iron-clad shipbuilding. Mr. Winslow became satisfied that Captain Ericsson's plans were both feasible and desirable. After conferring with his partner, Mr. Griswold, it was determined to lay the whole matter before President Lincoln. This was done in October, 1861. The earnestness with which Mr. Winslow and Mr. Griswold pressed the subject upon the attention of the President secured from him the promise that he would meet them on the next day at the office of Commodore Smith, a member of the board already referred to, and talk the subject over. The meeting took place. There were present Mr. Lincoln, the Secretary of the Navy, (Mr. Welles,) Commodore Smith, and other officials of the Navy Department. Mr. Winslow again presented the merits of Captain Ericsson's plans for the construction of the *Monitor*. The President expressed his wish that the subject should be still further investigated by Commodore Smith, and then withdrew. The interview resulted in a contract with Captain Ericsson and Messrs. Winslow & Griswold for the construction of the *Monitor*, the vessel to be placed in the hands of the Government within 100 days, at a cost of $275,000. Mr. C. S. Bushnell, the business associate of Captain Ericsson, also signed the contract. The contract, however, was burdened with many exacting conditions and restric-

tions, which amounted to almost a prohibition of the enterprise. The contractors, however, at once entered upon the important undertaking.

The hull of the vessel was built by Thomas F. Rowland, agent of the Continental iron works, at Green Point, Long Island, the plates, bars, and rivets being largely supplied to him by the Albany iron works of Winslow & Griswold. The Delamater iron works, of New York, were commissioned to manufacture the steam machinery, propellers, and internal apparatus of the turret. The Novelty iron works, of New York, built the turret, and the turret-plating and a part of the armor-plating, composed of a series of plates one inch thick, were rolled by H. Abbott & Son, of Baltimore. The port stoppers were assigned to Charles De Lancy, of Buffalo. The work was pushed with all diligence until the 30th of January, 1862, when the ship was launched at Green Point, 101 days from the execution of the contract. During its construction Captain Ericsson gave his personal attention to all the details, and the launching of the vessel in the remarkably brief period of 101 days from the signing of the contract was in large part the result of his untiring energy and devotion.

The first trial trip of the *Monitor* was on February 19, 1862, and on that day she was delivered to the navy-yard for her armament and stores. She made two trial trips afterwards. The first and second trips were not satisfactory, the first because the cut-off valve had been improperly set and would not admit the steam properly to the cylinders; the second from some slight defect in the steering apparatus, which was speedily corrected.

On the 13th of January, 1862, Lieutenant Worden, now rear-admiral, was ordered to the command of the *Monitor*, then on the stocks. On the 20th of February, 1862, he received sailing-orders from the Secretary of the Navy to proceed to Hampton Roads, Virginia, and there report to the Navy Department. On the afternoon of the 6th of March, 1862, the *Monitor*, with a picked crew from the war ships *North Carolina* and *Sabine*, fifty-eight officers and men all told, left the lower bay of New York, with a moderate wind and smooth sea, in tow of a small tug, the *Seth Low*, and accompanied by the United States steamers *Currituck* and *Sachem*. After encountering a severe storm the *Monitor* passed Cape Henry light-house at four o'clock on the afternoon of March 8th. At this point heavy firing in the direction of Fortress Monroe indicated an engagement, and very soon Lieutenant Worden learned from a pilot of the advent of the *Merrimac* and the disaster to the ships *Cumberland* and *Congress*. On the information received from the pilot Lieutenant Worden ordered the *Monitor* to be prepared for action, and at nine o'clock that evening anchored at Hampton Roads near the frigate *Roanoke*, to the commander of which Lieutenant Worden reported.

The next morning, March 9, 1862, the *Merrimac* was observed under way, steaming slowly from Sewell's Point, where she had anchored during the night to accomplish more perfectly her work of the day before. The *Monitor* immediately stood for her with crew at quarters, and the fierce and remarkable fight began, continuing from eight o'clock A. M. to one and a half o'clock P. M., and resulting in the discomfiture of the *Merrimac* and the full proof of all that had been claimed for the *Monitor*.

Orders for more monitors were at once given, and Captain Ericsson and the firm of Winslow & Griswold had the confidence and gratitude of the whole American people. The great regret was everywhere expressed that

the *Monitor* was not at Hampton Roads one day sooner to save the *Cumberland* and the *Congress* with the brave men who went down with them.

The life of the *Monitor* was as short as it was eventful. From the 10th of March until the destruction of the *Merrimac* on the 11th of May, 1862, she lay in Hampton Roads as a guard for the vast interests centred there. On the 12th of May she led the vessels which went to Norfolk on the evacuation of that city by the Confederates, and subsequently performed other services on the James river. In September she was at the Washington navy-yard for repairs, sailing again for Hampton Roads in November. On the 29th of December, 1862, she sailed for Beaufort, North Carolina, in company with the steamer *Rhode Island*, her convoy, and on the night of the 30th she foundered near Cape Hatteras, carrying down about one-half of her officers and crew.

Mr. Griswold died in 1872, but Captain Ericsson and Mr. Winslow are still living.

CHAPTER XLIII.

BRITISH EFFORTS TO PREVENT THE DEVELOPMENT OF THE AMERICAN IRON INDUSTRY.

MANY of the difficulties encountered in the early development of our iron and steel industries were inseparable from the conditions which attend the settlement of a new country, but others were of a political character, and grew out of the dependent relation of the colonies to Great Britain. The first Lord Sheffield declared that "the only use and advantage of American colonies or West India islands is the monopoly of their consumption and the carriage of their produce." McCulloch, in his *Commercial Dictionary*, admits that it was "a leading principle in the system of colonial policy, adopted as well by England as by the other European nations, to discourage all attempts to manufacture such articles in the colonies as could be provided for them by the mother country." Dr. William Elder, in his *Questions of the Day*, says: "The colonies were held under restraint so absolute that, beyond the common domestic industries, and the most ordinary mechanical employments, no kind of manufactures was permitted." Bancroft, in his *History of the United States of America*, says that "England, in its relations with other States, sought a convenient tariff; in the colonies it prohibited industry." He further says: "The British nation took no part in the strifes between the governors and the colonies; but they were jealously alive to the interests of their own commerce and manufactures. That the British creditor might be secure, lands in the plantations were, by act of Parliament, made liable for debts. Every branch of consumption was, as far as practicable, secured to English manufacturers; every form of competition in industry, in the heart of the plantations, was discouraged or forbidden." In 1750 appeared the celebrated deliverance of a prominent Englishman, Joshua Gee, in which he boldly proclaimed that the British people "ought always to keep a watchful eye over our colonies, to restrain them from setting up any of the manufactures which are carried on in

Great Britain, and any such attempts should be crushed in the beginning, for if they are suffered to grow up to maturity it will be difficult to suppress them." Henry C. Carey informs us, in his *Principles of Social Science*, that even the distinguished Lord Chatham "declared that he would not allow the colonists to make even a hobnail for themselves." Mathew Carey, in his *Essays on Political Economy*, says: "The great Chatham, the least hostile to British America of British ministers, in his speech in the House of Lords, on the address to the throne, in 1770, expressed his utmost alarm at the first efforts at manufactures in America."

A law of Virginia, passed in 1684, to encourage textile manufactures in that province, was annulled in England. In 1699 the exportation, by land or water, of wool and woolen manufactures from one colony to another was prohibited. This was done that the English woolen manufacturers might have a monopoly in supplying the colonists with woolen goods. From 1719 to 1732 British merchants "complained in memorials to the government that the people of Massachusetts, New York, Connecticut, Rhode Island, and Maryland were setting up manufactures of woolen and linen for the use of their own families, and of flax and hemp for coarse bags and halters." Bancroft says: "In the land of furs it was found that hats were well made: the London company of hatters remonstrated; and their craft was protected by an act forbidding hats to be transported from one plantation to another." "In 1732," says Henry C. Carey, in his great work above mentioned, "the exportation of hats from province to province was prohibited, and the number of hatters' apprentices was limited by law." In 1750 a hatter-shop in Massachusetts was declared by the British Parliament to be a nuisance.

Concerning the attitude of Great Britain toward the woolen manufactures of the colonies, at as late a period as the beginning of the Revolution, we quote from Adam Smith, in his *Wealth of Nations*, published in 1776: "She prohibits the exportation from one province to another by water, and even the carriage by land upon horseback or in a cart, of hats, of wools and woolen goods, of the produce of America; a regulation which effectually prevents the establishment of any man-

ufacture of such commodities for distant sale, and confines the industry of her colonists in this way to such coarse and household manufactures as a private family commonly makes for its own use, or for that of some of its neighbors in the same province."

In the seventeenth century the colonial iron industry was so slowly developed that it attracted but little attention in the mother country; but at the beginning of the eighteenth century, when Pennsylvania, Maryland, and Virginia began to manufacture iron and to export it to England, the possibilities of its development in competition with the English iron industry became a source of uneasiness to English iron-masters. In the following passage Bancroft details the results of this apprehension.

The proprietors of English iron works were jealous of American industry. In 1719 news came that, in some parts of Massachusetts, "the inhabitants worked up their wool and flax, and made a coarse sort for their own use; that they manufactured great part of their leather, that there were also hatters in the maritime towns; and that six furnaces and nineteen forges were set up for making iron." These six furnaces and nineteen forges were a terror to England, and their spectres haunted the public imagination for a quarter of a century. The House of Commons readily resolved that "the erecting manufactories in the colonies tended to lessen their dependence;" and, under pretense of encouraging the importation of American lumber, they passed a bill having the clause, "that none in the plantations should manufacture iron wares of any kind out of any sows, pigs, or bars whatsoever." The House of Lords added, "that no forge, going by water, or other works should be erected in any of the said plantations, for the making, working, or converting of any sows, pigs, or cast-iron into bar or rod iron." The opposition of the northern colonies defeated the bill; England would not yet forbid the colonists to manufacture a bolt or a nail; but the purpose was never abandoned.

The distinguished American historian records in the following language the culmination of the repressive policy of the mother country toward the iron industry of the colonies. "America abounded in iron ore; its unwrought iron was excluded by a duty from the English market; and its people were rapidly gaining skill at the furnace and the forge. In February, 1750, the subject engaged the attention of the House of Commons. To check the danger of American rivalry Charles Townshend was placed at the head of a committee. . After a few days' deliberation he brought in a bill which per-

mitted American iron in its rudest forms to be imported duty free; but, now that the nailers in the colonies could afford spikes and large nails cheaper than the English, it forbade the smiths of America to erect any mill for slitting or rolling iron, or any plating-forge to work with a tilt-hammer, or any furnace for making steel. . . . The house divided on the proposal that every slitting mill in America should be abolished. The clause failed only by a majority of twenty-two; but an immediate return was required of every mill already existing, and the number was never to be increased." The act of Parliament to which Bancroft here alludes contained many elaborate provisions, but its principal provisions were as follows:

WHEREAS, The importation of bar iron from His Majesty's colonies in America into the port of London, and the importation of pig iron from the said colonies, into any port of Great Britain, and the manufacture of such bar and pig iron in Great Britain, will be a great advantage, not only to the said colonies, but also to this kingdom, by furnishing the manufacturers of iron with a supply of that useful and necessary commodity, and by means thereof large sums of money, now annually paid for iron to foreigners, will be saved to this kingdom, and *a greater quantity of the woolen, and other manufactures of Great Britain, will be exported to America, in exchange for such iron so imported;* be it therefore enacted by the King's most excellent majesty, by and with the advice and consent of the Lords, spiritual and temporal, and Commons, in this present Parliament assembled, and by the authority of the same, that from and after the twenty-fourth day of June, one thousand seven hundred and fifty, the several and respective subsidies, customs, impositions, rates, and duties, now payable on pig iron, made in and imported from His Majesty's colonies in America, into any port of Great Britain, shall cease, determine, and be no longer paid; and that from and after the said twenty-fourth day of June, no subsidy, custom, imposition, rate, or duty whatever, shall be payable upon bar iron made in and imported from the said colonies into the port of London; any law, statute, or usage to the contrary thereof in any wise notwithstanding.

And, that pig and bar iron made in His Majesty's colonies in America *may be further manufactured in this kingdom,* be it further enacted by the authority aforesaid, that from and after the twenty-fourth day of June, one thousand seven hundred and fifty, no mill or other engine for slitting or rolling of iron, or any plateing forge to work with a tilt hammer, or any furnace for making steel, shall be erected, or after such erection continued in any of His Majesty's colonies in America; and if any person or persons shall erect, or cause to be erected, or after such erection continue, or cause to be continued, in any of the said colonies, any such mill, engine, forge, or furnace, every person or persons so offending shall, for every such mill, engine, forge, or furnace, forfeit the sum of two hundred pounds of lawful money of Great Britain.

And it is hereby further enacted by the authority aforesaid, that every such mill, engine, forge, or furnace, so erected or continued, contrary to the directions of this act, *shall be deemed a common nuisance*, and that every governor, lieutenant-governor, or commander-in-chief of any of His Majesty's colonies in America, where any such mill, engine, forge, or furnace, shall be erected or continued, shall, upon information to him made and given, upon the oath of any two or more credible witnesses, that any such mill, engine, forge, or furnace, hath been so erected or continued, (which oath such governor, lieutenant-governor, or commander-in-chief, is hereby authorized and required to administer,) order and cause every such mill, engine, forge, or furnace, to be abated within the space of thirty days next after such information given and made as aforesaid.

The provision in the above act which repealed the duties on colonial pig iron and on bar iron imported into the port of London was wholly based on the necessities of the mother country, and was not in the least due to a desire to build up a colonial iron industry for the benefit of the colonies themselves. There was in 1750 a scarcity of wood in England for the supply of charcoal, which was then the principal fuel used in the smelting and refining of iron, but forests everywhere abounded in the colonies, and iron ore had been found in many places. The manufacture of pig iron and bar iron in the colonies, and their exportation to England, to meet a scarcity of the domestic supply of these raw products, and to be exchanged for British woolen and other manufactures, was therefore encouraged. The provision relating to articles made *from* pig iron and bar iron was intended to be prohibitory of their manufacture in the colonies. Adam Smith thus described in 1776 the character of this legislation, which had not been repealed nor altered down to that period, the beginning of our Revolution: "While Great Britain encourages in America the manufactures of pig and bar iron, by exempting them from duties to which the like commodities are subject when imported from any other country, she imposes an absolute prohibition upon the erection of steel furnaces and slit-mills in any of her American plantations. She will not suffer her colonists to work in those more refined manufactures even for their own consumption, but insists upon their purchasing of her merchants and manufacturers all goods of this kind which they have occasion for."

Bancroft comments as follows upon the reception which was given in England to the new law.

While England applauded the restriction, its owners of iron mines grudged to America a share of the market for the rough material; the tanners, from the threatened inaction of the English furnaces, feared a diminished supply of bark; the clergy and gentry foreboded injury to the price of woodlands. The importation of bar iron from the colonies was therefore *limited to the port of London, which already had its supply from abroad.* The ironmongers and smiths of Birmingham thought well of importing bars of iron free; but, from "compassion" to the "many thousand families in the kingdom" who otherwise "must be ruined," they prayed that "the American people" might be subject not to the proposed restrictions only, but to such others "as may secure for ever the trade to this country." Some would have admitted the raw material from no colony where its minute manufacture was carried on.

The act of 1750 was generally enforced in the colonies, and the further erection of slitting and rolling mills, plating forges, and steel furnaces was prevented. Works of the character described which had been erected previous to the passage of the act could not, however, be legally prevented from continuing in operation. The governors of the several colonies issued proclamations commanding obedience to the requirements of the new law. The proclamation of lieutenant-governor James Hamilton, of Pennsylvania, was printed by Benjamin Franklin. An original copy may be seen in the library of the Pennsylvania Historical Society. It reads as follows:

By the Honourable James Hamilton, Esq., Lieutenant-Governor and Commander-in-Chief of the Province of Pennsylvania and Counties of New Castle, Kent, and Sussex, on Delaware.

A PROCLAMATION.

Whereas, By an act of Parliament passed in the twenty-third year of His Majesty's reign, entituled "An act to encourage the importation of pig and bar iron from His Majesty's colonies in America, and to prevent the erection of any mill, or other engine, for slitting or rolling of iron, or any plating-forge to work with a tilt-hammer, or any furnace for making steel in any of the said colonies," it is enacted—"That from and after the twenty-fourth day of June, in the year of our Lord one thousand seven hundred and fifty, every governor, lieutenant-governor, and commander-in-chief of any of His Majesty's colonies in America, shall forthwith transmit to the commissioners for trade and plantations, a certificate, under his hand and seal of office, containing a particular account of every mill or engine for slitting and rolling of iron, and every plating-forge to work with a tilt-hammer, and every furnace for making steel, at the time of the commencement of this act, erected in his colony; expressing, also, in the said certificate, such of them as are used, and the name or names of the proprietor or pro-

prietors of each such mill, engine, forge, and furnace, and the place where each such mill, engine, forge, and furnace is erected, and the number of engines, forges, and furnaces in the said colony." To the end therefore that I may be the better enabled to obey the directions of the said act, I have thought fit, with the advice of the council, to issue this proclamation, hereby enjoining and requiring the proprietor or proprietors, or in case of their absence, the occupiers of any of the above-mentioned mills, engines, forges, and furnaces, erected within this province, to appear before me, at the city of Philadelphia, on or before the twenty-first day of September next, with proper and ample testimonials of the rights of such proprietor, proprietors, and occupiers therein, and sufficient proofs whether the said mills, engines, forges, and furnaces respectively were used on the said twenty-fourth day of June or not: And I do further hereby require and command the sheriff of every county in this province respectively, on or before the said twenty-first day of September, to appear before me, at the city of Philadelphia aforesaid, and then and there by writings, under their hands and seals, to certify and make known to me, every mill or engine for slitting and rolling of iron, every plating-forge to work with a tilt-hammer, and every furnace for making steel, which were erected within their several and respective counties, on the said twenty-fourth day of June, and the place and places where the same were erected, with the names of their reputed proprietor or proprietors, and the occupiers of them, and every of them; and whether they or any of them were used on the said twenty-fourth day of June or not, as they and each of them will answer the contrary at their peril.

Given under my hand and the great seal of the province of Pennsylvania, at Philadelphia, this sixteenth day of August, in the twenty-fourth year of the reign of our Sovereign Lord, GEORGE the Second, King of Great Britain, France, and Ireland, etc., and in the year of our Lord 1750.

By His Honour's command. JAMES HAMILTON.

RICHARD PETERS, *Secretary*.

GOD Save the KING.

PHILADELPHIA: Printed by B. FRANKLIN, Printer to the Province, MDCCL.

As may easily be imagined the passage of this act aroused anew the feeling of discontent in the colonies which had been created and kept alive by many repressive measures of the mother country directed against our colonial manufactures. These measures of repression formed a large part of that "long train of abuses and usurpations" which led to the war of independence.

From the passage of the act of 1750 down to the Revolution our iron industry was mainly confined to the production of pig iron and bar iron, and of castings from the blast furnace. The effect of the act was to repress the development of our steel industry and of the finished branches of our iron industry. During this period we made pig iron and bar

iron in sufficient quantities for our own use, and the surplus was sent to the mother country.

But the colonies suffered also from the general restrictive policy of Great Britain affecting the manufactures of all foreign countries, particularly from its numerous acts of Parliament prohibiting the exportation of skilled artisans and improved machinery. Adam Smith gives us the following view of this policy.

By the 7th and 8th of William III. [1696 and 1697], chapter 20, section 8, the exportation of frames or engines for knitting gloves or stockings is prohibited under the penalty not only of the forfeiture of such frames or engines so exported, or attempted to be exported, but of forty pounds—one-half to the king, the other to the person who shall inform or sue for the same.

By the 5th George I. [1718], chapter 27, the person who shall be convicted of enticing any artificer of, or in any of the manufactures of, Great Britain, to go into any foreign parts in order to practice or teach his trade, is liable, for the first offense, to be fined in any sum not exceeding one hundred pounds, and to three months' imprisonment, and until the fine shall be paid; and, for the second offense, to be fined in any sum at the discretion of the court, and to imprisonment for twelve months, and until the fine shall be paid. By the 23d George II. [1749], chapter 13, this penalty is increased, for the first offense, to five hundred pounds for every artificer so enticed, and to twelve months' imprisonment, and until the fine shall be paid; and, for the second offense, to one thousand pounds, and to two years' imprisonment, and until the fine shall be paid.

By the former of those two statutes, upon proof that any person has been enticing any artificer, or that any artificer has promised or contracted to go into foreign parts for the purposes aforesaid, such artificer may be obliged to give security at the discretion of the court that he shall not go beyond the seas, and may be committed to prison until he give such security.

If any artificer has gone beyond the seas, and is exercising or teaching his trade in any foreign country, upon warning being given to him by any of his majesty's ministers or consuls abroad, or by one of his majesty's secretaries of state for the time being, if he does not within six months after such warning return to this realm, and from thenceforth abide and inhabit continually within the same, he is from thenceforth declared incapable of taking any legacy devised to him within this kingdom, or of being executor or administrator to any person, or of taking any lands within this kingdom by descent, devise, or purchase. He likewise forfeits to the king all his lands, goods, and chattels, is declared an alien in every respect, and is put out of the king's protection.

Sir William Blackstone, in the chapter on offenses against public trade, in his *Commentaries on the Laws of England*, re-

cites some of the details above given by Adam Smith, and adds important testimony to the character of the restrictive legislation adopted by Great Britain in 1774, during the long reign of George the Third. He says:

To prevent the destruction of our home manufactures by transporting and seducing our artists to settle abroad, it is provided, by statute 5 George I., c. 27, that such as so entice or seduce them shall be fined £100 and be imprisoned three months; and for the second offense shall be fined at discretion, and be imprisoned a year; and the artificers so going into foreign countries, and not returning within six months after warning given them by the British ambassador where they reside, shall be deemed aliens, and forfeit all their land and goods, and shall be incapable of any legacy or gift. By statute 23 George II., c. 13, the seducers incur, for the first offense, a forfeiture of £500 for each artificer contracted with to be sent abroad, and imprisonment for twelve months; and for the second, £1000, and are liable to two years' imprisonment; and, by the same statute, connected with 14 George III., c. 71, if any person exports any tools or utensils used in the silk, linen, cotton, or woolen manufactures (excepting wool cards to North America), he forfeits the same and £200, and the captain of the ship (having knowledge thereof) £100; and if any captain of a king's ship, or officer of the customs, knowingly suffers such exportation, he forfeits £100 and his employment, and is forever made incapable of bearing any public office; and every person collecting such tools or utensils in order to export the same shall, on conviction at the assizes, forfeit such tools and also £200.

The policy which is epitomized above by the great English political economist and the great English commentator was continued throughout the Revolution and long after the American colonies secured their independence. The details of British legislation at this period are worthy of preservation.

The following summary of the provisions of various restrictive acts of Parliament enacted in 1781, 1782, 1785, and 1795 is derived from Pope's *Laws of the Customs and Excise.*

(1781.) It was enacted (21 Geo. III., c. 37) that any person who packed or put on board, or caused to be brought to any place in order to be put on board any vessel, with a view to exportation, "any machine, engine, tool, press, paper, utensil, or implement, or any part thereof, which now is or hereafter may be used in the woolen, cotton, linen, or silk manufacture of this kingdom, or goods wherein wool, cotton, linen, or silk are used, or any model or plan thereof," etc., should forfeit every such machine and the goods packed therewith and £200, and suffer imprisonment for twelve months. The like penalties attached to having in custody or power, or collecting, making, applying for, or causing to be made, any such machinery, and the forfeitures were to go to the use of the informer after the expenses of prosecution were paid. The exportation, and the attempt to put

on board for that purpose, of "any blocks, plates, engines, tools, or utensils used in, or which are proper for the preparing or finishing of, the calico, cotton, muslin, or linen printing manufactures, or any part thereof," were the next year (1782) prohibited under penalty of £500. The same act interdicted the transportation of tools used in the iron and steel manufactures.

(1785.) The great improvements which had been made in England in all branches of the iron manufacture, and the competition springing up in Europe and America in the production of raw iron, doubtless prompted the act of 1785 (25 Geo. III., c. 67) to prevent, under severe penalties, the enticing of artificers or workmen in the iron and steel manufactures out of the kingdom, and the exportation of any tools used in these branches to any place beyond the seas.

(1795.) The act of Parliament of 1785, prohibiting the exportation of tools and machinery used in the iron and steel manufactures, was made perpetual by the statute 35 Geo. III., c. 38. It recapitulates the several descriptions of machines, engines, implements, utensils, and models, or parts thereof, employed in rolling, slitting, pressing, casting, boring, stamping, piercing, scoring, shading, or chasing and die-sinking iron and other metals. It included machines used in the button, glass, pottery, saddle and harness, and other manufactures, wire moulds for paper, etc.

We copy below the leading provisions of the act of the British Parliament, (chapter 37,) adopted in 1781, the twenty-first year of the reign of George the Third, which prohibited the exportation from Great Britain of machinery used in the manufacture of cotton, linen, woolen, and silk goods.

An act to explain and amend an act made in the fourteenth year of the reign of his present Majesty, intituled, An Act to prevent the exportation to foreign parts of utensils made use of in the cotton, linen, woollen, and silk manufactures of this kingdom, . . . That if, at any time after the twenty-fourth day of June, one thousand seven hundred and eighty-one, any person or persons in Great Britain or Ireland shall . . . put on board of any ship or vessel, which shall not be bound directly to some port or place in Great Britain or Ireland, . . . any machine, engine, tool, press, paper, utensil, or implement whatsoever, which now is, or at any time or times hereafter shall or may be used in, or proper for the preparing, working, pressing, finishing, or completing, of the woollen, cotton, linen, or silk manufactures of this kingdom . . . ; or any model or plan, or models or plans, of any such machine, engine, tool, press, paper, utensil, or implement, or any part or parts thereof, . . . the person or persons so offending shall, for every such offence, not only forfeit all such machines, engines, tools, press, paper, utensils, or implements, models or plans, or parts thereof respectively, together with the packages, and all other goods packed therewith, if any such there be, but also the sum of two hundred pounds of lawful money of Great Britain; and shall also suffer imprisonment . . . for the space of twelve months, without bail or mainprize, and until such forfeiture shall be paid.

The act of 1785, in the twenty-fifth year of the reign of George the Third, and just one hundred years ago, was undisguisedly passed to cripple if possible the iron industries of foreign countries. Its principal provisions were as follows:

An act to prohibit the exportation to foreign parts of tools and utensils made use of in the iron and steel manufactures of this kingdom; and to prevent the seducing of artificers or workmen, employed in those manufactures, to go into parts beyond the seas.

Whereas, the exportation of the several tools and utensils made use of in preparing, working up, and finishing the iron and steel manufactures of this kingdom, or either of them, will enable foreigners to work up such manufactures, and thereby greatly diminish the exportation of the same from this kingdom; therefore, for the preserving, as much as possible, to His Majesty's subjects the benefits arising from those great and valuable branches of trade and commerce, be it enacted, that if, at any time, after the first day of August, one thousand seven hundred and eighty-five, any person or persons in Great Britain shall, upon any pretence whatsoever, export, load, or put on board, or pack, or cause or procure to be loaden, put on board, or packed, in order to be loaded or put on board of any ship or vessel which shall be bound to some port or place in parts beyond the seas (except to Ireland), or shall lade, or cause or procure to be laden, on board any boat or other vessel, or shall bring, or cause to be brought, to any quay, wharf, or other place, in order to be so laden or put on board any such ship or vessel, any tool or utensil hereafter mentioned; that is to say, hand stamps, dog head stamps, pulley stamps, stamps of all sorts, hammers and anvils for stamps, screws for stamps, iron rods for stamps, presses of all sorts, in iron, steel, or other metal, which are used for giving impressions to metal, or any parts of these several articles; presses of all sorts called cutting-out presses, beds and punches to be used therewith; piercing presses of all sorts, beds and punches to be used therewith, either in parts or pieces, or fitted together; iron or steel dies to be used in stamps or presses either with or without impressions on them; *rollers of cast iron, wrought iron, or steel, for rolling of metal, and frames for the same;* flasks or casting moulds, and boards used therewith; lathes of all sorts for turning, burnishing, polishing, either the whole together, or separate parts thereof; lathe strings, polishing brushes, scoring or shading engines, presses for horn buttons, dies for horn buttons, sheers for cutting of metal, rolled steel, rolled metal, with silver thereon, parts of buttons not fitted up into buttons, or in an unfinished state; engines for chafing, stocks for casting buckles, buttons, and rings; *cast-iron anvils and hammers for forging mills for iron and copper; roles, slitters, beds, pillars, and frames for slitting mills;* die-sinking tools of all sorts, engines for making button shanks, laps of all sorts, drilling engines, tools for pinching of glass, engines for covering of whips, polishing brushes, bars of metal covered with gold or silver, *iron or steel screw plates, pins, and stocks for making screws,* or any other tool or utensil whatsoever, which now is, are, or at any time or times hereafter shall or may be used in, or proper for the preparing, working, finishing, or completing of the iron or steel manufactures of this kingdom, or either of them, by what name or names soever

the same shall be called or known, *or any model or plan*, or models or plans, of any such tool, utensil, or implement, or any part or parts thereof; the person or persons so offending shall for every such offence not only forfeit and lose all such tools or utensils, or parts or parcels thereof, together with the packages, and all other goods packed therewith, if any such there be, . . . the person or persons so offending shall, for every such offence, forfeit the sum of two hundred pounds of lawful money of Great Britain, and shall also suffer imprisonment, in the common gaol, prison, or house of correction, . . . for the space of twelve months, without bail or mainprize, and until such forfeiture shall be paid.

And whereas, *for the encouragement of such manufactories in this kingdom, it is necessary that provision should be made to prevent artificers, and others employed therein, from departing, or from being seduced to depart out of this kingdom;* be it therefore enacted by the authority aforesaid, that from and after the said first day of August, one thousand seven hundred and eighty-five, if any person or persons shall contract with, entice, persuade, or endeavor to seduce or encourage any artificer or workman concerned or employed, or who shall have worked at, or been employed in, the iron or steel manufactures in this kingdom, or in making or preparing any tools or utensils for such manufactory, to go out of Great Britain to any parts beyond the seas (except to Ireland), and shall be convicted thereof . . . shall, for every artificer so contracted with, enticed, persuaded, encouraged, or seduced, or attempted so to be, forfeit and pay the sum of five hundred pounds of lawful money of Great Britain, and shall be committed to the common gaol, . . . there to remain without bail or mainprize for the space of twelve calendar months, and until such forfeiture shall be paid; and in case of a subsequent offence of the same kind, the person or persons so again offending shall, upon the like conviction, forfeit and pay, for every person so contracted with, enticed, persuaded, encouraged, or seduced, or attempted so to be, the sum of one thousand pounds of lawful money of Great Britain, and shall be committed to the common gaol as aforesaid, there to remain, without bail or mainprize, for and during the term of two years, and until such forfeitures shall be paid.

In 1786 some trifling changes were made in the list of articles the exportation of which was prohibited, but the principal tools used in the manufacture of iron and steel were carefully preserved in the list. At the same time tools for making paper, for making and working glass, and for making pottery and harness were added to the list. In 1795, as already stated, the act of 1785 was made perpetual. In 1799 an act was passed providing that, "Whereas, there have of late been many attempts to seduce colliers out of Scotland into foreign countries, be it therefore further enacted that all persons seducing, or attempting to seduce, colliers . . . from the kingdom of Great Britain shall be punished in the same manner as persons seducing, or attempting to seduce, man-

ufacturers or other artisans are punishable by law." This last act would have a tendency to prevent the mining of coal in the United States, which had scarcely been commenced at the time of its passage.

The prohibition of the exportation of machinery for the manufacture of iron and steel, and of other machinery, continued until long after the beginning of the present century. In 1825 and again in 1833 the exportation of machinery for the manufacture of cotton, woolen, linen, and silk goods was again *specifically prohibited.* It was not permitted to be exported until 1845. In the London *Times* for October 30, 1811, will be found a circumstantial account of the arrest of Hugh Wagstaff for placing on board the American ship *Mount Vernon,* bound to New York, twenty-three boxes containing spindles used in the spinning of cotton. Wagstaff was committed to Lancaster Castle for trial under the act of 21 Geo. III., chapter 37, and the boxes were seized. The Hon. John L. Hayes, of Boston, the highest authority in the United States upon the literature of our textile industries, informs us that "the patriotic Tench Coxe, the able coadjutor of Alexander Hamilton in the Treasury, entered into a bond with a person in London, who engaged to send him complete models of Arkwright's patents. The models were completed and packed, but were detected and forfeited." In 1832 the model of a roller for calico printing, to be used at Lowell, in Massachusetts, could be obtained from England only by concealing it in the trunk of a lady who was returning to this country. From a letter in the possession of Dr. Hayes it appears that when, in 1839, Messrs. Sharp & Roberts, of Manchester, England, desired to introduce their self-acting mule into this country, after obtaining a patent for it here, their American partner, Mr. Bradford Durfee, of Fall River, was compelled to smuggle through France the patterns for the castings. The statutes interfering with the emigration of artificers were not wholly repealed until 1825.

During the long period in the history of the mother country in which she endeavored by the legislation above recited to repress the development of our manufacturing industries she vigorously protected her own industries by customs duties from foreign competition. The protection which she

gave to her iron industry after Cort had perfected for her the puddling furnace and the rolling mill, and the owners of her blast furnaces had generally introduced steam-power and the use of mineral fuel, is especially noticeable. Prior to this time Great Britain had not made enough iron to supply her own wants; now she could do this. We quote as follows from Scrivenor's *History of the Iron Trade.*

From 1782 till 1795 the duty on foreign bars was £2 16s. 2d. per ton. It rose to £3 4s. 7d. in 1797; from 1798 to 1802 it was £3 15s. 5d.; in two years it had got to £4 17s. 1d.; from 1806 to 1808 it stood at £5 7s. 5¾d.; in the three years between 1809 and 1812 it was £5 9s. 10d.; and in the five years ending with 1818 it had been £6 9s. 10d. At this date a distinction was made in the interest of British shipping; for whilst thenceforward, till the close of 1825, the duty on foreign bars was £6 10s. if imported in British ships, it was £7 18s. 6d. if imported in foreign. Nor was this all; iron slit, or hammered into rods, and iron drawn down, or hammered, less than three-quarters of an inch square, was made to pay a duty at the rate of £20 per ton; wrought iron, not otherwise enumerated, was taxed with a payment of £50 for every £100 worth imported; and steel, or manufactures of steel, were similarly loaded with a fifty per cent. duty.

It does not fall within the scope of this work to discuss the revenue policy of the British Government at any period of the history of this country further than to show its effects in depressing the development of our iron and steel industries. This has been done. As germane, however, to what has already been presented the following additional testimony concerning the hostile policy of the British Government and people toward American manufacturing industries in the present century is of historical value.

In 1816 Lord Brougham, in a speech in Parliament advocating the increased exportation of British goods to the United States, declared that "it was well worth while to incur a loss upon the first exportation, in order by the glut to stifle in the cradle those rising manufactures in the United States which the war has forced into existence contrary to the natural course of things." Mr. Robertson, a member of Parliament, said in a memorable speech quoted by Henry Clay in 1832: "It was idle for us to endeavor to persuade other nations to join with us in adopting the principles of what was called free trade. Other nations knew, as well as the noble lord opposite and those who acted with him, what we meant

by free trade was nothing more nor less than, by means of the great advantages we enjoyed, to get a monopoly of all their markets for our manufactures, and to prevent them, one and all, from ever becoming manufacturing nations." In 1843 the London *Spectator* said: "More general considerations tend to show that the trade between the two countries, most beneficial to both, must be what is commonly called a colonial trade; the new-settled country importing the manufactures of the old, in exchange for its own raw produce. In all economical relations the United States still stand to England in the relation of colony to mother country." In 1854 a British Parliamentary commission declared: "The laboring classes generally in the manufacturing districts of this country, and especially in the iron and coal districts, are very little aware of the extent to which they are often indebted for their being employed at all to the immense losses which their employers voluntarily incur in bad times in order to destroy foreign competition, and to gain and keep possession of foreign markets. . . . The large capitals of this country are the great instruments of warfare against the competing capital of foreign countries."

CHAPTER XLIV.

EFFECTS OF FOREIGN COMPETITION UPON THE AMERICAN IRON INDUSTRY AFTER THE REVOLUTION.

During the Revolution and immediately after its close the iron industry of Great Britain was greatly stimulated by the general substitution of bituminous coal for charcoal, by the application of the steam engine to the blowing of furnaces, and by the introduction of the puddling furnace and grooved rolls in the refining and finishing of iron. These improvements greatly increased and cheapened the iron products of Great Britain, so that, instead of being dependent upon this country for a supply of pig iron and bar iron, she was enabled to send these and other iron products to her former colonies in successful competition with their own manufactures. The effect was to greatly retard the extension of our iron industry after the Revolution. The competition which produced this result might have been averted if the emancipated colonies had followed the example of the mother country and imposed duties upon foreign iron and steel that would have protected the domestic manufacture of these products. But they did not do this, although the desire for industrial independence was one of the leading causes of the Revolution, and although the fact was fully recognized after our political independence was secured that domestic manufactures were greatly in need of the protection against foreign competition which only high duties could give to them. Under the Articles of Confederation and for many years after the establishment of our "more perfect union" duties upon foreign imports of every description were so low that they afforded no adequate protection to American manufactures. From 1789 to 1812 the duties on pig iron and bar iron ranged from only 5 per cent. to 19¼ per cent. of their value. In the same years the duty on steel ranged from 50 cents to $1.10 per cwt. These were but little else than revenue duties. During all of this period our manufactures did not flourish. They languished because of foreign competition.

The following petition, presented to the General Assembly of Pennsylvania on November 30, 1785, two years before the framing of the Federal Constitution, shows the effect at that time of foreign competition, principally from the mother country, upon the manufacture of bar iron in Pennsylvania. It will be remembered that under the Articles of Confederation each State reserved to itself the control of all duties upon imported foreign commodities—a reservation which worked so badly in many ways that the creation of our present form of government soon became a necessity from this cause alone. Pennsylvania had, however, been slow to assert the need of protection for some of her infant manufactures, as the fate of the petition referred to will testify.

To the Honorable the Representatives of the Freemen of the Commonwealth of Pennsylvania in General Assembly met.

The petition of the subscribers, manufacturers of bar iron within the Commonwealth aforesaid, respectfully sheweth.

That, by an act passed during the last session of the late Assembly, additional duties are laid on the importation of divers manufactures of Europe and other foreign parts, for the purpose of protecting and encouraging the manufactures of this State, wherein your petitioners find the article of bar iron has been omitted.

That the manufacturing of bar iron within this State has not only been found very useful and important during the late war, but has always been considered as a source of public wealth and benefit; as great sums of money were thereby kept within the country; which circulating through the hands of several thousand persons, employed in the manufactures of bar iron and furnishing the requisite materials, enabled them to maintain themselves and their families and contribute to the support of government by payment of taxes—and an influx of specie and other considerable advantages were also derived to the trade of this State by the exportation of great quantities of bar iron to other parts of the continent.

That, although most of the iron manufactured within this State is confessedly superior in quality to the iron imported from foreign parts, yet, because iron can not be manufactured at so low a price here as in countries where the laborers are but little removed above the condition of slaves, the sale of divers large quantities of foreign iron lately imported into this State, notwithstanding its inferior quality, operates so much to the prejudice of all persons concerned in the manufacture of bar iron here, that there is great reason to apprehend, unless the legislature shall extend their aid, further importations of foreign iron will in a short time occasion a total stoppage and destruction of that very useful and beneficial manufacture amongst us.

Your petitioners trust that, on full consideration of the premises, the manufacture of bar iron within this State will appear to your Honorable House essentially entitled to public protection and encouragement, and therefore pray your Honorable House may be pleased to grant relief in the

premises by laying such additional duties on foreign bar iron as will prevent further importations thereof becoming destructive or oppressive to the manufacture of bar iron within this State.

And your petitioners as in duty bound shall ever pray, &c.

Jacob Morgan, Jr.	John Patton.	James Old.
David Potts.	George Ege.	Jno. Edwards.
James Hartley.	Jacob Winey.	William Bird.
Andw. Pettitt.	Valentine Eckert.	Jacob Leshet.
Jesse Grunfield.	Peter Grubb, Jr.	Michl. Ege.
Thos. Humphreys.	Curtis Grubb.	Jn. Hellings.
Thos. Rutter.	Peter Grubb, Sr.	Abrm. Sharples.
Thos. Mayburry.	Robt. Coleman.	Hilary Baker.
Saml. Potts.	Matthias Hough.	C. Douglass.
J. Hockley.	William Olde.	Richd. Backhouse.
Wm. Hayes.	David Jenkins.	

This petition was referred on the day of its presentation to a committee composed of Mr. Fitzimmons, Mr. Clymer, and Mr. Whitehill, who submitted an adverse report on the 7th of December, as follows: "That with respect to bar iron it appears that a sufficient quantity may be made in the State, not only for its particular use, but a large overplus for exportation, but that, by the large importations lately made, the price is so much reduced as to disable the owners of forges to go on with their business. Your committee, however, viewing bar iron as necessary to the agriculture and manufactures of the State, are doubtful of the propriety of imposing a tax upon the importation thereof at this time." The committee, however, recommended the imposition of an additional duty of one penny per pound on all nails or spikes imported into the State. The report of the committee was adopted.

Further evidence of the injurious effects of foreign competition upon our domestic iron industry immediately after the peace is furnished in the following extract from the account of Dr. John D. Schoepf's travels in the United States, published at Erlangen in 1788.

America is richly supplied with iron, especially in the mountainous districts, and the ore is moreover easily obtained; nevertheless, and in spite of the abundance of wood, at present European iron can be brought to America cheaper than the founders and forgers of that place are able to produce it, by reason of the high wages of the workmen. The owners of the iron works in the different provinces, particularly in Pennsylvania and Jersey, tried in vain to induce their governments to prohibit the importation of foreign iron, or to clog it with high duties. As this proposition conflicted directly with the interests of the members of the assembly, as well as with those of their fel-

low countrymen, it certainly could not be expected that they should decide to pay dearer for their native iron and iron implements, when foreigners could supply them cheaper. Formerly the Americans were able to send their pig and bar iron to England with advantage, for they were relieved of the heavy tax which Russian and Swedish iron paid there. This was the case principally from the middle colonies, and in the year 1768–'70 the exports to England amounted to about 2,592 tons of bar iron and 4,624 tons of pig iron, with which they paid for a part at least of their return cargoes in England. In return they took back axes, hoes, shovels, nails, and other manufactured iron implements, for, although some of these articles were occasionally manufactured in America just as good as in Europe, yet it could not be done under at least three times the cost. Therefore, up to this time, the manufacture of cast iron alone has been found to be particularly advantageous.

It was not until our second war with Great Britain that duties were so increased as to be really protective of domestic industries against foreign competition. But these duties were subsequently reduced, and again all our industries languished. The tariffs of 1824 and 1828 again revived them, but subsequent tariff legislation was for many years so fitful and in the main so unfriendly that no American industry can truthfully be said to have been placed upon a substantial basis of prosperity until after the adoption of the Morrill tariff at the beginning of the civil war, in 1861. The protective policy which was then reaffirmed has since continued in force without material modification, and the marvelous progress of the country in the years that have since elapsed is mainly the result of its beneficent operations.

The Morrill tariff act, as might be erroneously inferred from its date, was not a war measure, but a measure rendered absolutely necessary by the depressed condition of our manufacturing industries and by the low condition of the national finances before the war-cloud arose. The bill was reported to the House of Representatives on March 12, 1860, by Mr. Morrill, of Vermont, from the Committee on Ways and Means, and passed that body on May 10th. It passed the Senate on February 20, 1861, and was approved by President Buchanan on March 2d. It took effect on April 1st of the same year.

Statistics to be presented in a subsequent chapter will show how slowly our iron and steel industries were developed after the Revolution and far into the present century. Foreign competition was not the sole cause of this slow growth, but it was one of the principal causes.

CHAPTER XLV.

IMPEDIMENTS TO THE CHEAP PRODUCTION OF IRON AND STEEL IN THE UNITED STATES.

The iron and steel industries of the United States are subject to permanent disadvantages from which the same industries of other countries are in a great measure relieved. It is true that it can not now be said, as it was once said, that they lack the skill, or the capital, or the extensive and complete establishments of other countries. They are no longer infant industries in any sense. Nor can it be said that the natural resources for the manufacture of iron and steel in our country are not abundant and varied. But in comparison with the iron and steel industries of other countries they are at a disadvantage in two important particulars. The wages of labor are much higher in this country than in any other iron-making country in the world; and the raw materials of production, rich and abundant as they are, are in the main so remote from each other that a heavy cost for their transportation is incurred to which no other iron-making country is subjected.

With reference to wages a single illustration will show the disparity which exists in the iron and steel industries of this country and Europe. At Pittsburgh the price of puddling, or boiling, iron was fixed for one year on the 30th of May, 1881, in an agreement between the employers and their workmen, at a *minimum* of $5.50 per ton, the price to be advanced if the price of bar iron should advance above 2½ cents per pound. Of the $5.50 the puddler's helper received about one-third. These rates of wages still continue. At Philadelphia, in an agreement between the employers and their workmen, on the 24th of July, 1880, the *minimum* price of puddling was fixed for an indefinite period, which still continues, at $4 per ton, of which sum the helper receives about one-third. When the price of bar iron is 2½ cents per pound the price of puddling is to be $4.50 per ton, the helper to receive about one-third. If the price of bar iron advances beyond 2½ cents per pound

the price of puddling is to be advanced. The Pittsburgh schedule of wages for puddling prevails in the western parts of the United States, and the Philadelphia schedule is fairly representative of the wages paid in eastern rolling mills.

Now let these rates of wages be compared with the corresponding rates which prevail in England, in which country the wages of iron and steel workers are usually higher than in any other part of Europe. The North of England is the principal seat of the iron industry of that country. A board of arbitration and conciliation for the manufactured-iron trade of the North of England adjusts the wages of all rolling-mill workmen in the district every three months, upon the basis of the average net selling price of rolled iron during the three months preceding the month in which the board meets. The average net selling price of rolled iron for the three months which ended on the 30th of June, 1881, (a period of prosperity and good prices,) was £6 2s. 2d., and the wages of puddlers for the three months beginning on the 1st of August was officially declared to be 7s. per ton, or about $1.75, of which sum the puddler's helper, in accordance with the English custom, received about one-third. The official announcement of the adjustment of wages, dated July 29th, is as follows: "In accordance with the sliding-scale arrangement and the resolution of the employers' meeting of February 24th the above-named figure of £6 2s. 2d. gives 7s. per ton as the rate for puddling over the three months commencing on the 1st of August, and a reduction of other forge and mill wages of 2½ per cent. upon last quarter." The same system of adjusting wages prevails in the North of England to-day, and wages are no higher now than in 1881. The difference in puddlers' wages in the North of England and in this country in the same periods of time is thus seen to be very great. The wages of other rolling-mill workmen in both countries closely correspond to the wages paid to puddlers.

With regard to the cost of transporting raw materials in the United States and Europe the testimony of a distinguished English ironmaster will be sufficient to show the great disparity which exists in the distances over which they must be transported. Mr. I. Lowthian Bell, a commissioner from Great Britain to the Philadelphia Exhibition of 1876, says in

his official report: "The vast extent of the territory of the United States renders that possible which in Great Britain is physically impossible; thus it may and it does happen that in the former distances of nearly 1,000 miles may intervene between the ore and the coal, whereas with ourselves it is difficult to find a situation in which the two are separated by even 100 miles." From the iron-ore mines of Michigan and Minnesota to the coal of Pennsylvania is 1,000 miles. Connellsville coke is taken 600 miles to the blast furnaces of Chicago, and 750 miles to the blast furnaces of St. Louis. The average distance over which all the domestic iron ore which is consumed in the blast furnaces of the United States is transported is not less than 400 miles, and the average distance over which the fuel which is used to smelt it is transported is not less than 200 miles. Great Britain is our principal competitor in the production of iron and steel. In France, Germany, Belgium, Sweden, and other European iron-making countries the raw materials of production may not be found in such close proximity as in Great Britain, but they lie much nearer to each other than is usual in the United States. Even when it is necessary to transport raw materials from one European country to another, as in taking the iron ores of Spain to England or Germany, the cost of removal is usually an unimportant consideration because of the short distances they are carried and the facilities which in most cases exist for carrying them by water. When this country is obliged, from any cause whatever, to import iron ores from Spain or from Mediterranean ports the cost of transportation across the Atlantic and from Atlantic ports inland imposes a heavy tax upon the consumer.

But it is not only on the raw materials that the cost of transportation operates as an impediment to European prices for iron and steel products in this country. The manufactured products themselves must frequently be transported long distances to find consumers. The conditions favorable to the production of iron and steel are not equal in many sections of the Union, and in some sections do not exist at all; iron and steel can not, therefore, be extensively or profitably manufactured in all sections. The country, too, is of vast extent, while its railroad and other enterprises which consume

iron and steel are found in every part of it. It is noticeable, also, that railroads form the principal means of communication between the producers and consumers of iron in this country, and that railroad transportation is much more expensive than transportation by natural water routes. Heavy products of iron and steel, for instance, can be carried much more cheaply from Liverpool to the gulf ports of the United States than from our own rolling mills and blast furnaces which are not situated on the sea-coast or on the Mississippi river, and very few of them are so situated. Iron and steel rails for railroads on the Pacific coast can be carried more cheaply from Liverpool to San Francisco than from Chicago or St. Louis. Even to ports on the Atlantic coast it can truthfully be said that, taking them as a whole, British iron and steel products can be carried more cheaply than from our own iron and steel works which are located only a short distance in the interior. No freight is better adapted to the ballasting of ships which come to this country for grain and cotton than heavy products of iron and steel, and these products are therefore usually carried at very low rates. Ocean freight charges afford no protection to our iron and steel manufacturers.

So much are high wages and the high cost of transportation hindrances to the cheap production of iron and steel in this country that English newspapers frequently boast of the superior facilities possessed by British manufacturers in this respect. The London *Colliery Guardian* for January 25, 1884, remarks upon this subject as follows: "The very smallness of Great Britain tells in its favor as a manufacturing country. Raw materials have to be carried comparatively limited distances, and coal, iron, and labor are collected and brought together with extreme ease, while the manufactured article, when ready for exportation, has to be carried only a few miles to some convenient port. All these elements of industrial success are more or less lacking in the United States. Labor is still comparatively scarce there and has to be remunerated at higher rates, while coal and iron have to be hauled great distances before they become available for use. When manufactured goods are turned out they have also in many cases to be carried heavy distances before they can be put on board ship."

CHAPTER XLVI.

STATISTICS OF THE IRON AND STEEL INDUSTRIES OF THE UNITED STATES.

In this chapter we present a summary of the iron and steel statistics of the United States from the earliest periods for which such information is obtainable to the present time. The sources of information relied upon in compiling this summary are mainly the records of the Census Office and of The American Iron and Steel Association.

No tabulated statistics of the production of iron in our colonial history are extant, and the materials for such a compilation appear to be entirely wanting; nor do the census statistics of the United States contain any reference to the industries of the country until 1810.

In 1814 there was published *A Statement of the Arts and Manufactures of the United States of America*, as they existed in 1810, prepared by Tench Coxe, under the authority of Albert Gallatin, Secretary of the Treasury. From this statement we derive the following information concerning the condition of our iron industry in 1810.

Establishments and products.	United States.	Pennsylvania.
Number of blast furnaces Number of air furnaces	153	44 6
Tons of cast iron made	53,908	26,878
Value of cast iron made	$2,981,277	$1,301,343
Number of bloomaries	135	4
Tons of iron made	2,564	....
Value of iron made	$226,034	$16,000
Number of forges	330	78
Tons of bar iron, etc., made	24,541	10,969
Value of bar iron, etc., made	$2,874,063	$1,156,405
Number of trip hammers	316	50
Product of trip hammers in tons	600	....
Value of product of trip hammers	$327,898	$73,496
Rolling and slitting mills	34	18
Tons of rolled iron made Product of slit iron in tons	9,280	4,502 98
Value of rolled and slit iron	$1,215,946	$606,426
Number of nailleries	410	175
Pounds of nails made	15,727,914	7,270,825
Value of nails made	$2,478,139	$760,862

In the totals for the United States above given we believe the values to be correct, as they include returns from every State, but some of the quantities given are not strictly accurate, because some of the States did not report quantities, although they reported values.

The product of the steel furnaces in Massachusetts, Rhode Island, New Jersey, Pennsylvania, Virginia, and South Carolina in 1810 was 917 tons, valued at $144,736. Of the whole number of steel furnaces Pennsylvania contained 5, of which Philadelphia city and Philadelphia, Lancaster, Dauphin, and Fayette counties each contained one. The product of Pennsylvania was 531 tons, valued at $81,147.

In the census year 1820 the value of all the manufactures of pig iron and castings in the United States was $2,230,275, of which Pennsylvania's share was $563,810. In the same year the country produced "manufactures of wrought iron" of the value of $4,640,669, of which Pennsylvania's share was $1,156,266. Quantities were not given.

In the census year 1830 the value of the pig iron and castings manufactured in the United States was $4,757,403, of which the share of Pennsylvania was $1,643,702. In the same year the country's production of "manufactures of wrought iron" amounted in value to $16,737,251, of which Pennsylvania's share was $3,762,847. Quantities were not given.

In the census year 1840 there were in the United States 804 furnaces, which produced in that year 286,903 tons of "cast iron." Pennsylvania had 213 furnaces, and produced 98,395 tons of "cast iron." In the same year there were 795 bloomaries, forges, and rolling mills in the country, of which Pennsylvania had 169. The number of tons of bar iron produced in that year was 197,233, of which Pennsylvania produced 87,244 tons.

In the census year 1850 there were produced in the United States 563,755 tons of pig iron by 377 establishments, of which Pennsylvania produced 285,702 tons in 180 establishments. In the same year the country produced "wrought iron manufactures" of the value of $22,629,271 in 552 establishments, Pennsylvania contributing $9,224,256 in value in 162 establishments.

In the census year 1860 the United States, in 97 establishments, produced 51,290 tons of blooms, worth $2,623,178; Pennsylvania, in 57 establishments, produced 24,700 tons of blooms, worth $1,467,450. In the same year the United States, in 286 establishments, produced 987,559 tons of pig iron, worth $20,870,120; Pennsylvania, in 125 establishments, produced 580,049 tons of pig iron, worth $11,262,974. In 256 establishments the United States produced 513,213 tons of rolled iron, worth $31,888,705; Pennsylvania, in 87 establishments, produced 266,253 tons of rolled iron, worth $15,122,842. In 13 establishments the United States produced 11,838 tons of steel, worth $1,778,240; Pennsylvania, in 9 establishments, produced 9,890 tons of steel, worth $1,338,200.

The statistics of our iron and steel industries in the census years 1870 and 1880 are given herewith in comparative statements. These statistics embrace the number, production, etc., of the *blast furnaces, rolling mills, steel works, pig-iron and scrap-iron forges, and ore bloomaries* in the United States in the census years mentioned. It is important to bear this classification in mind.

The ton used in the census statistics of 1810, 1840, 1850, and 1860 was the gross ton of 2,240 pounds, but in the census statistics of 1870 and 1880 the net ton of 2,000 pounds was used.

The whole number of establishments that were engaged in the manufacture of iron and steel in 1880, or were built or partly built to engage in their manufacture, was 1,005. In 1870 it was 808. The increase in the ten years was 24.38 per cent. By the term "establishment" is meant a single manufacturing enterprise, or an aggregation of enterprises of like character under one management. The number of blast-furnace establishments in 1870 was 386, and in 1880 it was 490. The number of blast furnaces in 1870 was 574, and in 1880 it was 681, an increase of 18.64 per cent.; the number of rolling mill establishments in 1870 was 310, and in 1880 it was 324; the number of steel works in 1870 was 30, and in 1880 it was 73; the number of pig-iron and scrap-iron forges and of ore bloomaries in 1870 was 82, and in 1880 it was 118. The size and capacity of the establishments were generally much greater in 1880 than in 1870.

The whole amount of capital invested in 1880 in the iron and steel industries of the United States which have been above enumerated was $230,971,884; in 1870 it was $121,772,074: increase, $109,199,810, or 89.68 per cent. Of the whole amount invested in 1880 Pennsylvania's share was 46 per cent.; that of Ohio was 11 per cent.; that of New York was 9 per cent.; and that of Missouri and New Jersey was 4 per cent. each. No one of the other States shows an investment greater than 3 per cent.

The total production of the iron and steel works of the United States in 1880 was 7,265,140 net tons; in 1870 it was 3,655,215 tons: increase, 3,609,925 tons, or 98.76 per cent. The phrase "total production" includes the products of all the various processes or operations, although in ascertaining most of these products there is a necessary duplication of the tonnage of raw or comparatively raw materials. Thus, rolled iron is mainly produced from pig iron. As the method of stating the production of 1880 is the same that was observed in 1870 a comparison of the results for both periods can not be open to objection.

The following table shows the production of each branch of our iron and steel industries in 1870 and 1880, with the percentage of increase or decrease in the latter year.

Iron and steel products.	Census year 1870.	Census year 1880.	Percentage of increase in 1880.	Percentage of decrease in 1880.
	Net tons.	*Net tons.*		
Pig iron and castings from furnaces.	2,052,821	3,781,021	84	....
All products of iron rolling mills......	1,441,829	2,353,248	63	....
Bessemer steel finished products......	19,403	889,896	4,486	....
Open-hearth steel finished products.	....	93,143	....	....
Crucible steel finished products........	28,069	70,319	151	....
Blister and other steel.....................	2,285	4,956	117	....
Products of forges and bloomaries...	110,808	72,557	....	35
Total...	3,655,215	7,265,140	98.76	....

Of the pig iron produced in the census year 1880 there were produced with charcoal and cold blast, 79,613 tons; with charcoal and hot blast, 355,405 tons; with anthracite, 1,112,735 tons; with bituminous coal and coke, 1,515,107 tons; and with mixed anthracite and coke, 713,932 tons. The furnace

castings amounted to only 4,229 tons. The total production was 3,781,021 tons, of which 12,875 tons were spiegeleisen.

The relative rank in production of all the States and Territories that produced iron or iron and steel in 1870 and in 1880 is given in the following table.

States.	Production. 1880.	Rank.	States.	Production. 1870.	Rank.
	Net tons.			*Net tons.*	
Pennsylvania	3,616,668	1	Pennsylvania	1,836,808	1
Ohio	930,141	2	Ohio	449,768	2
New York	598,300	3	New York	448,257	3
Illinois	417,967	4	New Jersey	115,262	4
New Jersey	243,860	5	Maryland	95,424	5
Wisconsin	178,935	6	Missouri	94,890	6
West Virginia	147,487	7	Kentucky	86,732	7
Michigan	142,716	8	Michigan	86,679	8
Massachusetts	141,321	9	Massachusetts	86,146	9
Missouri	125,758	10	West Virginia	72,337	10
Kentucky	123,751	11	Indiana	64,148	11
Maryland	110,934	12	Wisconsin	42,234	12
Indiana	96,117	13	Virginia	37,836	13
Tennessee	77,100	14	Tennessee	34,305	14
Alabama	62,986	15	Illinois	25,761	15
Virginia	55,722	16	Connecticut	25,305	16
Connecticut	38,061	17	Maine	17,138	17
Georgia	35,152	18	Georgia	9,634	18
Delaware	33,918	19	Delaware	8,307	19
Kansas	19,055	20	Alabama	7,060	20
California	14,000	21	Rhode Island	4,415	21
Maine	10,866	22	California	3,000	22
Wyoming Territory	9,790	23	North Carolina	1,801	23
Rhode Island	8,134	24	Vermont	1,525	24
New Hampshire	7,978	25	South Carolina	443	25
Vermont	6,620	26	Kansas	....	....
Colorado	4,500	27	Wyoming Territory	....	....
Oregon	3,200	28	New Hampshire	....	....
Nebraska	2,000	29	Colorado	....	....
Texas	1,400	30	Oregon	....	....
North Carolina	439	31	Nebraska	....	....
District of Columbia	264	32	Texas	....	....
South Carolina	....	....	District of Columbia	....	....
Total	7,265,140	....	Total	3,655,215	....

In the following table is presented a view of the principal centres of production of the iron and steel industries of the United States in the census year 1880. These centres are divided into two classes—the first comprising fifteen counties each of which produced over 100,000 tons of pig iron, blooms, and finished products, and the second comprising seventeen counties each of which produced over 60,000 and less than

100,000 tons. Six States are represented in the first class, and eight States in the second class.

Counties of the first class, producing over 100,000 tons.	Net tons.	Counties of the second class, producing between 60,000 and 100,000 tons.	Net tons.
1. Allegheny county, Pa	848,146	1. Lawrence county, Pa	88,443
2. Lehigh county, Pa	324,875	2. Lancaster county, Pa	87,019
3. Northampton county, Pa	322,882	3. Ohio county, W. Va	84,767
4. Cambria county, Pa	260,140	4. Will county, Ill	84,094
5. Cook county, Ill	248,479	5. Montour county, Pa	79,789
6. Dauphin county, Pa	223,676	6. Chester county, Pa	78,363
7. Mahoning county, Ohio	219,957	7. Warren county, N. J	76,622
8. Berks county, Pa	213,580	8. Trumbull county, Ohio	73,369
9. Cuyahoga county, Ohio	210,354	9. Lebanon county, Pa	73,149
10. Mercer county, Pa	182,881	10. Lawrence county, Ohio	70,794
11. Rensselaer county, N. Y	177,967	11. Schuylkill county, Pa	70,609
12. Montgomery county, Pa	168,628	12. Baltimore county, Md	69,944
13. Lackawanna county, Pa	151,273	13. Blair county, Pa	68,039
14. Milwaukee county, Wis	128,191	14. Essex county, N. Y	66,725
15. St. Louis county, Mo	102,644	15. Philadelphia county, Pa	65,983
		16. Wayne county, Mich	63,548
		17. Dutchess county, N. Y	61,637
Total (15 counties)	3,783,673	Total (17 counties)	1,262,894

Twelve States made over 100,000 tons each in 1880, but in 1870 only four States attained this prominent rank. Pennsylvania, which for more than a hundred years has been the leading iron-producing State in the Union, made in 1870 a fraction over 50 per cent. of the total product, and in 1880 it made a fraction under 50 per cent. At both periods its prominence in the production of iron and steel was virtually the same. From 1870 to 1880 it increased its production 97 per cent., or from 1,836,808 tons to 3,616,668 tons. Ohio was the second State in prominence in 1870, and it held the same rank in 1880. The third State in prominence in 1870 was New York, and it maintained this rank in 1880, but its growth fell far below that of its two sister States above mentioned. In the decade between 1870 and 1880 the iron industry was extended into many new States and Territories. Twenty-five States were engaged in the manufacture of iron or iron and steel in 1870. Thirty States, the District of Columbia, and Wyoming Territory made iron in 1880, and about one-half of these also made steel.

The percentage of total production in 1880 was distributed

as follows: Pennsylvania, 50 per cent.; Ohio, 13; New York, 8; Illinois, 6; New Jersey, 3; Wisconsin and West Virginia, each over 2 per cent.; Michigan and Massachusetts, each nearly 2 per cent.; Missouri, Kentucky, and Maryland, each over $1\frac{1}{2}$ per cent.; Indiana, over 1 per cent.; Tennessee, about 1 per cent.; and all other States and Territories, an aggregate of about 4 per cent.

The geographical centre of total production of the iron and steel industries of the United States is the point at which equilibrium would be established were the country taken as a plane surface, itself without weight but capable of sustaining weight, and loaded with its production of iron and steel, each ton exerting pressure on the pivotal point directly proportioned to its distance therefrom. The centre of production of iron and steel in the United States in the census year 1880 is found to be at 40° 43′ north latitude and 79° 20′ longitude west from Greenwich. This point is in Pennsylvania, on the boundary line between Armstrong and Indiana counties, and about 12 miles northeast of Apollo and 12 miles west of Indiana, Laufman & Co.'s rolling mill at Apollo being the nearest iron works. At the centre of production thus ascertained iron has never been manufactured in any form.

The total number of hands employed in 1880 was 140,978. Of the whole number 133,203 were men above 16 years old, and 45 were women above 15 years old; 7,709 were boys below 16 years old, and 21 were girls below 15 years old. The remarkably small number of 66 women and girls employed in the manufacture of iron and steel in 1880 will not escape notice, and is exceedingly creditable to our American civilization. The comparatively small number of boys employed is also worthy of notice.

The 140,978 persons who were employed in 1880 were paid \$55,476,785 as wages, or an average of \$393.51 for the year for each person. The average daily wages of skilled labor were \$2.59; of unskilled labor, \$1.24. The highest average daily wages of skilled labor were paid in Rhode Island, Colorado, and Wyoming Territory—\$4; the lowest in North Carolina—\$1.25. The highest average daily wages of unskilled labor were paid in Wyoming Territory—\$2; the next highest in Colorado and California—\$1.75; the lowest in North Caro-

lina—54 cents. It may be remarked of North Carolina that its iron industry in 1880 was wholly confined to the use of the primitive ore bloomary, and that the labor employed was largely that of colored men. The average daily wages paid in the four grand divisions were as follows: Eastern States—skilled, $2.70; unskilled, $1.21; Southern States—skilled, $2.09; unskilled, $1.03; Western States—skilled, $2.70; unskilled, $1.31; Pacific States and Territories—skilled, $3.50; unskilled, $1.75.

It is necessary to explain that the figures of "hands employed" and "wages paid" refer to the labor directly employed at the various iron and steel works of the country, and in the mining and other operations conducted in direct connection with these works. They do not include the labor employed in independent and often remote mining operations which supply our iron and steel industries with ore and coal and other raw materials. Nor do they include any considerable part of the labor employed in the transportation of raw materials from the sources of production to the places of consumption. If the "hands employed" and "wages paid" in these various contributory channels were added to the figures given in our tables the total number of persons directly supported by our iron and steel industries in 1880 and the total amount of wages paid to them would be largely increased and probably doubled.

It is also necessary to add the explanation, that there may be no excuse for perverting statistical facts, that the average amount of wages paid to each hand employed in our iron and steel industries in the census year 1880, namely, $393.51, does not imply that the hands employed were severally occupied *the whole* of that year in the production of iron and steel. Many of them were so employed only a part of the year. Ore miners, charcoal-burners, and workers at charcoal blast furnaces could not, from the nature of their several occupations, be steadily employed except under the most favorable circumstances. Others were employed only a part of the census year because of the enforced idleness at its beginning, through long depression in trade, of many establishments which were in active operation before its close. Others again were employed only a part of the year through sickness, ac-

cidents, and innumerable other causes. The general average of wages for the year would also be reduced by the comparatively low wages paid to the boys who were employed. It would also be an error to assume that the persons who were employed at our iron and steel works for only a part of the census year 1880 were unable to earn wages elsewhere when not so employed. The honest seeker after the whole truth concerning the wages paid by our iron and steel manufacturers to their workmen in the census year 1880 will note the *average daily wages paid*, and not the average yearly wages. The average daily wages of skilled labor were $2.59; of unskilled labor, $1.24.

The average number of hours of labor required per week in the iron and steel works of the United States in 1880 was 65. This gives a little less than 11 hours for each working day of the week. The average is high, in consequence of the general although not universal practice of operating blast furnaces seven days in the week, and in consequence also of the usual practice at blast furnaces, rolling mills, and steel works of working twelve-hour turns or shifts, which practice may require the presence of the workmen for that length of time, although they may not be, and generally are not, so long actually employed. The State which presents the highest average is Vermont—75 hours, while the lowest average in any of the States is found in Delaware and Kansas—56 hours. A still lower average is found in the District of Columbia—54 hours.

The following table has been compiled from the statistics of The American Iron and Steel Association, and is the most comprehensive contribution to the statistical literature of our iron and steel industries that has ever been published. It gives the production of all leading iron and steel products for a long series of years. It may be remarked, in explanation of the variations in the time at which the statistics of the different branches of our iron and steel industries begin, that the Association was unable for some years after its organization in 1855 to procure complete statistics of all the branches, owing to the extent of the country, the isolated situation of many establishments, and a lack of interest in statistical inquiries. These difficulties were all happily sur-

mounted many years ago. They did not, however, apply to the collection of the statistics of steel-rail production, which have easily been obtained since steel rails were first made in this country. This table most forcibly and eloquently tells the story of the marvelous growth of our iron and steel industries within the life-time of the present generation. It begins with 1849, the statistics of production obtained by the Association not going back to an earlier period.

Years.	Pig iron.	Rolled iron, including iron rails and nail plates.	Iron rails.	All kinds of steel rails.	Steel ingots and other crude steel.	Blooms from pig and scrap iron and iron ore.
	Net tons.	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*	*Net tons.*
1849	....	....	24,318	....	....	....
1850	....	....	44,083	....	....	....
1851	....	....	50,603	....	....	....
1852	....	....	62,478	....	....	....
1853	....	....	87,864	....	....	....
1854	736,218	....	108,016	....	....	....
1855	784,178	....	138,674	....	....	....
1856	883,137	....	180,018	....	....	....
1857	798,157	....	161,918	....	....	....
1858	705,094	....	163,712	....	....	....
1859	840,627	....	195,454	....	....	....
1860	919,770	....	205,038	....	....	....
1861	731,544	....	189,818	....	....	....
1862	787,662	....	213,912	....	....	....
1863	947,604	....	275,768	....	9,044	....
1864	1,135,996	872,327	335,369	....	10,369	....
1865	931,582	856,340	356,292	....	15,262	63,977
1866	1,350,343	1,026,089	430,778	....	18,973	73,555
1867	1,461,626	1,039,396	459,558	2,550	22,000	73,073
1868	1,603,000	1,097,775	499,489	7,225	30,000	75,200
1869	1,916,641	1,226,356	583,936	9,650	35,000	69,500
1870	1,865,000	1,291,000	586,000	34,000	75,000	62,259
1871	1,911,608	1,447,483	737,483	38,250	82,000	63,000
1872	2,854,558	1,847,922	905,930	94,070	160,108	58,000
1873	2,868,278	1,837,430	761,062	129,015	222,652	62,564
1874	2,689,413	1,694,616	584,469	144,944	241,614	61,670
1875	2,266,581	1,599,516	501,649	290,863	436,575	49,243
1876	2,093,236	1,509,269	467,168	412,461	597,174	44,628
1877	2,314,585	1,476,759	332,540	432,169	637,972	47,300
1878	2,577,361	1,555,576	322,890	559,795	819,814	50,045
1879	3,070,875	2,047,484	420,160	693,113	1,047,506	62,353
1880	4,295,414	2,332,668	493,762	968,075	1,397,015	74,589
1881	4,641,564	2,643,927	488,581	1,355,519	1,778,912	84,606
1882	5,178,122	2,493,831	227,874	1,460,920	1,945,095	91,293
1883	5,146,972	2,348,874	64,954	1,295,740	1,874,359	74,758

The growth of the iron and steel industries of the United States during the present century is comprehensively exemplified in the statistics of the production of our blast furnaces at various periods. The following table shows the production

of pig iron in the United States from 1810 until 1882, in tons of 2,240 pounds. The figures for the early periods have been carefully compiled from reliable sources of information and from the census reports; for 1870 and subsequent periods they have been taken from the records of The American Iron and Steel Association.

Years.	Gross tons.	Years.	Gross tons.	Years.	Gross tons.
1810	53,908	1840	286,903	1870	1,665,179
1820	20,000	1850	563,755	1880	3,835,191
1830	165,000	1860	987,559	1882	4,623,323

The exportation of bar iron from the American colonies began in 1717, when 2 tons of bars were sent to England from the British West India islands of Nevis and St. Christopher, but which had evidently been taken there from one of the Atlantic coast colonies. We present below a table, compiled from Scrivenor's *History of the Iron Trade*, showing the quantity of colonial iron exported to England from 1718 to 1776, inclusive. The colonies which made the shipments were New England, New York, Pennsylvania, Maryland, Virginia, and the Carolinas. They were not permitted to export their iron to any country but Great Britain, or one of its colonies, and not to Ireland until 1765.

Years.	Pig Iron.				Bar Iron.				Years.	Pig Iron.				Bar Iron.			
	Tons.	*cwt.*	*qr.*	*lbs.*	*Tons.*	*cwt.*	*qr.*	*lbs.*		*Tons.*	*cwt.*	*qr.*	*lbs.*	*Tons.*	*cwt.*	*qr.*	*lbs.*
1718	....	...	..	...	3	7	0	0	1751	3,210	11	1	0	5	4	2	9
1728-9	1,132	2	3	4	......	...	..	...	1752	2,980	1	3	2	81	7	0	26
1730	1,725	14	3	7	......	...	..	...	1753	2,737	19	3	27	247	19	3	11
1730-1	2,250	5	3	14	......	...	..	...	1754	3,244	17	1	23	270	15	1	4
1731-2	2,332	14	3	15	......	...	..	...	1755	3,441	2	3	8	389	18	3	20
1732-3	2,404	17	1	12	......	...	..	...	1761	2,766	2	3	12	39	1	0	0
1733	....	...	..	...		11	3	0	1762	1,766	16	0	2	122	12	2	14
1733-4	2,197	10	1	14	......	...	..	...	1763	2,566	8	0	25	310	19	3	2
1734	....	...	..	...			2	12	1764	2,554	8	3	21	1,059	18	0	10
1734-5	2,561	14	3	11	......	...	..	...	1765	3,264	8	1	22	1,078	15	0	16
1735	....	...	..	...	55	6	3	21	1766	2,887	5	1	15	1,257	14	3	9
1739	2,417	16	2	4	......	...	..	...	1767	3,313	2	1	19	1,325	19	0	18
1740	2,275	7	1	0	5	4	1	21	1768	2,953	0	2	14	1,989	11	0	6
1741	3,457	9	0	18	5	0	0	0	1769	3,401	12	2	2	1,779	13	1	23
1742	2,075	0	0	23	......	...	..	...	1770	4,232	18	1	18	1,716	8	0	21
1743	2,985	9	2	8	......	...	..	...	1771	5,303	6	3	13	2,222	4	3	24
1744	1,861	16	1	22	57	0	0	0	1772	3,724	19	2	25	965	15	0	23
1745	2,274	5	1	17	4	5	2	14	1773	2,937	13	0	2	837	15	0	6
1746	1,861	2	3	13	196	18	0	12	1774	3,451	12	2	19	639	0	0	23
1747	2,156	15	3	16	82	11	2	11	1775	2,996	0	2	24	916	5	2	11
1748	2,155	15	2	23	4	0	0	0	1776	316	1	2	8	28	0	0	0
1750	2,924	0	0	20	5	17	3	0									

In addition to the foregoing there were exported to Scotland 264 tons of pig iron and 11 tons of bar iron in ten years, from 1739 to 1749, and 229 tons of pig iron in six years, from 1750 to 1756. In 1770, as we learn from Timothy Pitkin's *Statistical View of the Commerce of the United States*, the following quantities of iron were exported to all countries, including England, which is given above separately: Pig iron, 6,017 tons, valued at $145,628; bar iron, 2,463 tons, valued at $178,891; castings, 2 tons, valued at $158; and wrought iron, 8 tons, valued at $810. These are all the particulars of our colonial export iron trade that are obtainable.

From 1776 to 1791 there is no record of any shipments abroad of American iron, although doubtless some iron was shipped in each year immediately after the peace. Since 1791 our exports of iron and steel, except in the form of machinery, have not constituted any considerable part of our foreign trade. Until 1840 our annual exports of iron and steel and manufactures thereof never amounted in value to one million dollars. In 1865 they first amounted to ten million dollars, and they have never since exceeded twenty million dollars.

The foreign value of the imports into the United States from all countries of iron and steel and manufactures thereof, including tin plates, in the thirteen calendar years from 1871 to 1883 is given in the following table, together with the value of the exports from the United States to all countries of domestic iron and steel and manufactures thereof in the same calendar years.

Imports.		Exports.	
Years.	Values.	Years.	Values.
1871	$57,866,299	1871	$11,836,137
1872	75,617,677	1872	10,030,125
1873	60,005,538	1873	12,129,939
1874	37,652,192	1874	15,389,807
1875	27,363,101	1875	16,092,906
1876	20,016,603	1876	11,798,459
1877	19,874,399	1877	16,659,675
1878	18,013,010	1878	13,260,369
1879	33,331,569	1879	12,470,448
1880	80,443,362	1880	12,960,995
1881	61,555,077	1881	15,782,202
1882	67,075,125	1882	19,029,759
1883	47,506,306	1883	19,025,718

The foregoing statistics of production and of imports and exports only tell the story of the growth of our iron and steel industries and of our consumption of iron and steel; the thoughtful reader will look for them to be accompanied by a record of the prices paid for leading products. This record is presented in the following tables. It goes back to the closing years of the last century, and comes down to the end of September, 1884. It is as complete as it has been possible to make it, and no pains have been spared to make it accurate. We have not attempted a compilation of colonial prices, but the curious reader will find occasional references to them in preceding pages.

The first table contains the average prices of charcoal pig iron at Philadelphia from 1799 to 1849, when anthracite pig iron became the standard of comparison. Until 1827 the prices are for the best pig iron; from 1827 to 1833 they are for an average of all grades; from 1833 to 1840 they are for gray iron; and from 1840 to the close of the table they are for No. 1 foundry. The first table also embraces the average prices of hammered bar iron at Philadelphia from 1794 to 1844, although its manufacture and sale, which had been declining prior to 1844, continued for several years afterwards.

In the second table the average prices of No. 1 anthracite foundry pig iron at Philadelphia are given from 1842, in which year quotations first appear, to 1884. In the same table the average prices of best refined rolled bar iron at Philadelphia are given from 1844 to 1884. In the same table the average prices of iron rails at Philadelphia are given from 1847 to 1883. In 1883 the manufacture of iron rails of standard sections in this country virtually came to an end, although the manufacture of light iron rails continues. A few standard iron rails, as well as light rails, were made in that year, but at higher prices than steel rails commanded. The column devoted to steel rails in the second table gives the average prices in Pennsylvania from 1867, when they were first made in commercial quantities, to 1884. The same table also gives the average prices at which anthracite coal has been sold by the cargo at Philadelphia from 1834 to 1884. The quotations are for hard white-ash lump coal. The tons used in the tables are tons of 2,240 pounds.

Table 1. Years.	Charcoal pig iron.	Hammered bar iron.
1794..........	....	$77 50
1795....	....	82 50
1796..........	....	106 50
1797..........	....	101 50
1798..........	....	97 50
1799.	$36 25	98 50
1800..........	35 75	100 50
1801..........	32 75	117 50
1802..........	30 75	99 00
1803..........	29 25	97 50
1804..........	29 75	98 50
1805..........	30 75	101 00
1806..........	35 75	108 50
1807..........	38 75	110 50
1808..........	40 00	104 00
1809..........	40 00	107 50
1810..........	38 00	108 00
1811..........	44 00	105 00
1812..........	47 50	106 00
1813..........	47 25	106 00
1814..........	46 00	133 00
1815..........	53 75	144 50
1816..........	50 25	127 00
1817..........	47 00	114 00
1818..........	42 25	110 00
1819..........	36 50	110 00
1820..........	35 00	103 50
1821..........	35 00	90 50
1822..........	35 00	94 50
1823..........	35 25	90 00
1824..........	40 00	82 50
1825..........	46 75	97 50
1826..........	46 50	101 50
1827..........	39 25	100 00
1828..........	35 00	100 00
1829..........	35 00	97 00
1830..........	35 00	87 50
1831..........	35 00	85 00
1832..........	35 00	85 00
1833..........	38 25	82 50
1834..........	30 25	82 50
1835..........	30 25	81 50
1836..........	41 50	100 00
1837..........	41 25	111 00
1838..........	32 25	93 50
1839..........	30 00	96 50
1840..........	32 75	90 00
1841..........	28 50	85 00
1842..........	28 00	83 50
1843..........	26 75	77 50
1844..........	28 25	75 00
1845..........	32 25	....
1846..........	31 25	....
1847..........	31 50	....
1848..........	28 50	....
1849..........	24 50	....

Table 2. Years.	No. 1 anthracite foundry pig iron.	Iron rails.	Steel rails.	Best refined rolled bar iron.	Schuylkill anthracite coal.
1834..........	....	....	....	....	$4 84
1835..........	....	....	....	....	4 84
1836..........	....	....	....	....	6 64
1837..........	....	....	....	....	6 72
1838..........	....	....	....	....	5 27
1839..........	....	....	....	....	5 00
1840....	....	....	....	....	4 91
1841..........	....	....	....	....	5 79
1842..........	$25 62	....	....	....	4 18
1843....	....	....	....	....	3 27
1844..........	25 75	....	....	$85 62	3 20
1845..........	29 25	....	....	93 75	3 46
1846..........	27 87	....	....	91 66	3 90
1847..........	30 25	$69 00	....	86 04	3 80
1848..........	26 50	62 25	....	79 33	3 50
1849..........	22 75	53 87	....	67 50	3 62
1850..........	20 87	47 87	....	59 54	3 64
1851..........	21 37	45 62	....	54 66	3 34
1852..........	22 62	48 37	....	58 79	3 46
1853..........	36 12	77 25	....	83 50	3 70
1854..........	36 87	80 12	....	91 33	5 19
1855..........	27 75	62 87	....	74 58	4 49
1856..........	27 12	64 37	....	73 75	4 11
1857..........	26 37	64 25	....	71 04	3 87
1858..........	22 25	50 00	....	62 29	3 43
1859..........	23 37	49 37	....	60 00	3 25
1860..........	22 75	48 00	....	58 75	3 40
1861....	20 25	42 37	....	60 83	3 39
1862..........	23 87	41 75	....	70 42	4 14
1863..........	35 25	76 87	....	91 04	6 06
1864..........	59 25	126 00	....	146 46	8 39
1865..........	46 12	98 62	....	106 38	7 86
1866..........	46 87	86 75	....	98 13	5 80
1867..........	44 12	83 12	$170 00	87 08	4 37
1868..........	39 25	78 87	158 50	85 63	3 86
1869..........	40 62	77 25	132 25	81 66	5 31
1870..........	33 25	72 25	106 75	78 96	4 39
1871..........	35 12	70 37	102 50	78 54	4 46
1872..........	48 87	85 12	112 00	97 63	3 74
1873..........	42 75	76 66	120 50	86 43	4 27
1874..........	30 25	58 75	94 25	67 95	4 55
1875..........	25 50	47 75	68 75	60 85	4 39
1876..........	22 25	41 25	59 25	52 08	3 87
1877..........	18 87	35 25	45 50	45 55	2 59
1878..........	17 62	33 75	42 25	44 24	3 22
1879..........	21 50	41 25	48 25	51 85	2 70
1880..........	28 50	49 25	67 50	60 38	4 53
1881..........	25 12	47 12	61 12	58 05	4 53
1882..........	25 75	46 37	48 50	61 41	4 61
1883..........	22 38	45 50	37 75	50 30	4 54
1884..........	20 00	....	31 75	43 30	4 42

A study of the foregoing tables reveals many and wide fluctuations in prices. The greatest uniformity will be found during the charcoal era, ending about 1844, allowance being made for the disturbing effects of the second war with Great Britain. The greatest fluctuations will be found since the close of that era, not counting the great enhancement in values during the civil war. In other words, before we began to produce iron largely, and especially while we held to the old ways of manufacturing it, the market for its sale was least excited and least depressed. The new methods reduced prices to lower figures than they had ever touched during the charcoal era, and the rebound has frequently been proportionately greater than at any time during that era. Until we began to manufacture pig iron with anthracite coal its yearly price after 1798 never fell below \$29 per ton, but in 1878 the average price for the year of No. 1 anthracite foundry pig iron was \$17.62. Until we began to roll the most of our bar iron, instead of hammering it, its yearly price after 1794 did not fall below \$77.50 per ton, but in 1883 the average price for the year was \$43.30, or a little less than two cents per pound. The greatest fall in prices has been in steel rails, which are now, at the close of 1884, sold at less than one-sixth the price charged for them when we began their manufacture in 1867.

When anthracite coal first became a marketable commodity in large quantities the price of the kind quoted in the table was much higher than was afterwards obtained for it. In 1826 it sold at from \$7 to \$7.80 per ton; in 1827, at \$7; in 1829, at from \$7.25 to \$7.50; in 1830, at from \$5.75 to \$7.25; in 1833, at from \$4.87½ to \$6. These prices do not appear in the table. The lowest yearly price at which anthracite coal has been sold in this country was in 1877, when it cost only \$2.59 per ton by the cargo.

The position of the United States among iron and steel producing countries at the present time is correctly indicated in the following table of the world's production of pig iron and steel of all kinds, which we have compiled from the latest and most reliable statistics that are accessible. This table places the world's production of pig iron in 1883 at 21,076,571 tons, and the world's production of steel in the same year at 6,277,691 tons. The percentage of pig iron produced by the

United States was nearly 22, and its percentage of steel was 27. For comparison we have added the latest coal statistics of the world. They show the percentage of production by the United States to be 24. English tons of 2,240 pounds are used in giving the statistics of Great Britain, the United States, Russia, and "other countries," and metric tons of 2,204 pounds for all the Continental countries of Europe except Russia. As the difference between the gross ton and the metric ton is so trifling it is not necessary to change official figures.

Country.	Pig iron.		Steel.		Coal.	
	Year.	Tons.	Year.	Tons.	Year.	Tons.
Great Britain	1883	8,490,224	1883	2,158,880	1883	163,737,327
United States	1883	4,595,510	1883	1,673,534	1883	96,159,719
Germany and Luxemburg	1883	3,397,588	1883	1,066,920	1883	70,223,456
France	1883	2,067,387	1883	509,045	1883	21,446,199
Belgium	1883	770,659	1883	220,000	1883	18,134,880
Austria and Hungary	1883	655,221	1883	271,732	1882	15,555,292
Russia	1881	462,042	1881	292,360	1881	3,437,840
Sweden	1882	399,001	1882	62,203	1882	250,000
Spain	1880	85,939	1873	216	1880	847,128
Italy	1883	53,000	1876	2,800	1882	220,000
Other countries	1882	100,000	1883	20,000	1883	8,000,000
Total	....	21,076,571	....	6,277,690	....	398,011,841
Percentage of United States	....	22	....	27	....	24

It is not contended that all of the details in the above table are absolutely accurate; at the present stage of statistical inquiry even in highly civilized countries this would be impossible. Most of the details are, however, derived from official sources, while others are from unofficial sources, and only those relating to "other countries" have been estimated.

CHAPTER XLVII.

SOME OF THE IMPORTANT USES OF IRON AND STEEL IN THE UNITED STATES.

IN Dr. Ure's *Dictionary of Arts, Manufactures, and Mines* we find this comprehensive and eloquent description of iron: "Every person knows the manifold uses of this truly precious metal. It is capable of being cast in moulds of any form; of being drawn out into wires of any desired strength or fineness; of being extended into plates or sheets; of being bent in every direction; of being sharpened, hardened, and softened at pleasure. Iron accommodates itself to all our wants, our desires, and even our caprices; it is equally serviceable to the arts, the sciences, to agriculture, and war; the same ore furnishes the sword, the ploughshare, the scythe, the pruning-hook, the needle, the graver, the spring of a watch or of a carriage, the chisel, the chain, the anchor, the compass, the cannon, and the bomb. It is a medicine of much virtue, and the only metal friendly to the human frame."

The people of the United States are the largest *per capita* consumers of iron and steel in the world, and of all nations they are also the largest aggregate consumers of these products. Our annual consumption of iron and steel has for several years averaged about 220 pounds for every man, woman, and child in the United States, and has aggregated an average of nearly six million tons. Great Britain makes more iron and steel than we do, but she exports about one-half of all the iron that she makes, and much more than one-half of all the steel. We estimate Great Britain's annual *home* consumption of iron and steel in late years as less than 200 pounds *per capita*. Her aggregate annual consumption of iron and steel has averaged about four million tons in late years, but of this quantity a large part is eventually exported to other countries in the form of iron ships, machinery, cutlery, etc. No other European country equals Great Britain either in the *per capita* or aggregate consumption of iron and steel, although Germany now follows her very closely in both

respects. Our own country annually imports large quantities of both products, Great Britain being the principal source of our foreign supply. Our exports of iron and steel, except in the form of machinery, are only nominal.

A simple enumeration of some of the more important uses to which iron and steel are applied by our people will show how prominent is the part these metals play in the development of American civilization and in the advancement of our greatness and power as a nation.

We have built more miles of railroad than the whole of Europe, and have used in their construction as many rails, and now use in their equipment almost as many railroad cars and locomotives. At the close of 1883 this country had 121,000 miles of railroad, Europe had about 110,000 miles, and all the rest of the world had about 50,000 miles. The United States had 21 miles of railroad to every 10,000 of population, while Europe had a little more than 3 miles to the same population. Railroads, it is well known, annually consume in rails, bridges, cars, and locomotives more than one-half of the world's production of iron and steel. The street railway is an American invention which also consumes large quantities of iron and steel, and we are far in advance of every other nation in its use. We were also the first nation in the world to introduce elevated railways especially to facilitate travel in large cities. Beauty of design, fitness of parts, and strength of materials have been so perfectly combined in the construction of our New York elevated railways as to excite the admiration of all who behold them. We are the foremost of all nations in the use of iron and steel in bridge-building for railroads and ordinary highways, and the lightness and gracefulness of our bridges are nowhere equaled, while their strength and adaptability to the uses for which they are required are nowhere surpassed. The steel wire in the Brooklyn bridge, which is in many respects the most notable bridge in the world, is all of American manufacture. In the use of iron for steam, water, and gas pipes we are probably in advance of every other nation. The Holly system of steam distribution in cities is an American invention; so is the Holly system of water supply. We make more iron stoves for heating halls and dwellings and for the purposes of

the kitchen than all the rest of the world, and in the use of heaters and ranges we are in advance of every other nation. Our household stoves, both for heating and cooking, are works of real art as well as of utility. They are ornaments of American homes, instead of being conveniences simply. Our heating stoves are especially handsome, bright, cheerful, healthful, and clean. In all respects they form the best combination of desirable qualities yet devised for the heating of private dwellings. Cooking and other domestic utensils of iron have always, even in our colonial days, been freely used in American households. We make liberal use of both cast and wrought iron in the construction of public and private buildings. Our use of iron for these purposes has in late years been quite notable, and in no respect more so than in the truly artistic effects which we give to this metal. We probably excel all nations in the use of iron for ornamental purposes in connection with masonry, brick-work, and wood-work. Fine illustrations of the artistic combination of iron with other materials may be seen in the interior of the new State Department building at Washington and in the interior of the new passenger station of the Pennsylvania Railroad at Philadelphia. We consume large quantities of wire rope in our extended and varied mining operations, and we lead the world in the use of iron and steel wire for fencing purposes. We have more miles of telegraph wire in use than any other country. The electric telegraph is an American invention; so is barbed wire fencing. We have made creditable progress in the construction of iron ships, and we would have made much greater progress if the same encouragement that has been given by other nations to their shipping interests had been given to ours. We use immense quantities of plate iron in the storage, transportation, and refining of petroleum, in the production of which nature has given us almost a monopoly. The oil wells themselves yearly require thousands of tons of iron pipes for tubing. We make liberal use of plate and sheet iron in the construction of the chimneys of steamboats on our lakes and rivers, and in the construction of factory, rolling-mill, and blast-furnace chimneys, and the stacks of blast furnaces. The jackets of hot-blast stoves also consume large quantities of plate iron. American planished sheet iron has

almost entirely superseded Russia sheet iron in our markets. We use it for locomotive jackets, in the manufacture of stoves and stove-pipe, and for many other purposes. We are the largest consumers of tin plates in the world, Great Britain, their principal manufacturer, sending us annually more than three-fourths of her total exports; indeed we consume more tin plates than all the rest of the world. Our portable and stationary steam engines consume large quantities of iron and steel. Portable engines are widely used in the lumber districts of this country, and are rapidly coming into use in threshing grain upon American farms. Our extensive mining operations require the most powerful stationary engines, as do also our various manufacturing enterprises. Steam cranes, steam hoists, steam elevators, steam dredges, steam hammers, and steam and hydraulic pumps require large quantities of iron and steel. Our beautiful steam fire-engines are the product of American taste and skill, if they are not strictly an American invention, and we annually make large numbers of them for home use and for exportation. Anchors and chains, cotton-presses and cotton-ties, sugar-pans and salt-pans, and general foundry and machine work annually require large quantities of either iron or steel. We make our own cotton and woolen manufacturing machinery, and nearly all the other machinery that we use. The manufacture of the printing presses of the country consumes immense quantities of iron and steel. No other country makes such free use of the printing press as this country. We are the leading agricultural nation of the world, and hence are the largest consumers of agricultural implements; but we are also in advance of every other nation in the use of agricultural machinery, the best of which we have invented. Our use of iron and steel in the manufacture of agricultural implements and agricultural machinery takes rank next to their use in the construction and maintenance of railroads. We lead all nations in the manufacture of cut nails and spikes. Having a larger and more rapidly-increasing population than any other country that is noted for its consumption of iron we are consequently the largest consumers of nails and spikes in the construction of dwellings and public buildings, stores, warehouses, and similar structures. The nail-cut-

ting machine is an American invention. Wire nails are just coming into general use in this country. Our manufactures of scales and balances, letter-presses, burglar-proof and fire-proof safes, sewing-machines, and wagons and carriages consume iron and steel in large quantities. Sewing-machines are an American invention. We use more pleasure carriages in proportion to population than Great Britain, France, Germany, or any other nation. Considerable quantities of iron or of iron and steel are used for sewer and other gratings, street-crossings, iron pavements, lamp-posts, posts and frames for awnings, posts for electric lights, fire-plugs, fire-escape ladders, builders' hardware and all sorts of small hardware, horse-shoes and horseshoe nails, wire rope for miscellaneous purposes, iron hoops, iron cots and bedsteads, iron burial caskets, iron chairs and settees, woven-wire mattresses, iron screens, iron railings, street letter-boxes, and fire-arms. In the manufacture of machine and hand tools and general cutlery we are excelled by no other nation, and in the use of machine tools we are in advance of every other nation. No other country makes such free use of labor-saving inventions of all kinds as this country, most of which require iron and steel in their construction. In general cutlery our saws and axes especially enjoy a world-wide reputation. Not the least important use to which iron and steel are put in this country is in the extension of the iron industry itself, every blast furnace, rolling mill, or steel works that is erected first consuming large quantities of these products before contributing to their general supply.

In the substitution of steel for iron this country is rapidly progressing, especially in the construction and equipment of its railroads. During the past few years fully four-fifths of all the rails that have been laid on American railroads have been made of Bessemer steel, and at present a still larger proportion of steel rails is required by our railroad companies. Indeed the manufacture of iron rails in this country is practically ended, steel rails now costing much less than iron rails. On several American railroads the boilers of all new locomotives are now required to be made of steel, and the tendency is toward the exclusive use of steel for locomotive boilers and its general use for stationary and marine boilers. The tires of

American locomotives are now made exclusively of steel, and the fire-boxes of our locomotives are generally made of steel. The steel used in the construction of American locomotives is now chiefly produced by the open-hearth process. We have built a few steel bridges, and there is a marked tendency to substitute steel for iron in bridge-building. In shipbuilding we have commenced the use of steel as a substitute for iron. The use of steel for building purposes has recently been commenced in this country, and it is now making rapid headway. Steel is now largely used in the manufacture of wire for miscellaneous purposes, and for car and carriage axles, carriage tires, screws, bolts, rivets, and many other articles for which iron was formerly used exclusively. All of our barbed wire fencing is made of steel. Steel has not yet been much used in this country for nails and horseshoes, but extensive preparations are now being made at Wheeling and elsewhere for the manufacture of nails from Bessemer steel.

Mention has been made of the artistic finish of some of our iron-work, but the subject seems worthy of further notice. It is not only in stove-founding, in the graceful designs of bridges and elevated railways, and in the delicate combination of iron with other materials in the construction and ornamentation of buildings that American iron-workers have displayed an exquisite taste and a bold and dexterous touch. The fine arts themselves are being enriched by the achievements of our iron-working countrymen. An iron foundry at Chelsea, in Massachusetts, has recently reproduced, in iron castings, various works of art with all the fidelity and delicacy of Italian iron-founders. The most delicate antique patterns have been successfully copied. Shields representing mythological groups and classic events, medallions containing copies of celebrated portraits, panels containing flowers and animals, an imitation of a Japanese lacquer tray one-sixteenth of an inch thick, and a triumphal procession represented on a large salver comprise some of the work of the Chelsea foundry. Some of the castings have been colored to represent bronze and others to represent steel, while others again preserve the natural color of the iron. The bronzed castings resemble beaten work in copper. American iron is chiefly used. Other foundries have produced similar castings.

The ornamental uses to which art castings of iron may be put are many, and as they can be cheaply produced it may be assumed that a demand will ere long be created for them that will be in keeping with the artistic taste which has been so generally developed in our country during the past few years.

We conspicuously fall behind many other nations in the use of iron and steel for military purposes. We maintain only a small standing army and a small navy, and hence have but little use for iron or steel for the supply of either of these branches of the public service. We are also behind all other nations in the use of iron and steel sleepers for railroad tracks. We yet have an abundance of timber for railroad cross-ties, and hence do not need to substitute either iron or steel cross-ties. Except possibly as an experiment there is not an iron or steel cross-tie in use in this country. It is a singular fact that we still import many blacksmith's anvils, their manufacture being a branch of the iron business to which we have not yet given adequate attention. Anvils of the best quality are, however, made in this country. A far more serious hiatus in our iron industry is found in the total absence of the manufacture of tin plates, which are almost entirely composed of sheet iron, as is well known. As we can import the crude tin as easily as we import other commodities, our failure thus far to manufacture tin plates must be ascribed to the only true cause, our inability to manufacture sheet iron and coat it with tin as cheaply as this is done by British manufacturers. Tin ore has recently been discovered in this country in several places, and it is not improbable that it may yet be produced at home in sufficiently large quantities to supply any domestic demand that may be created for its use. The foreign value of the tin plates imported by the United States in 1883 amounted to $18,156,773, the whole supply coming from Great Britain.

CHAPTER XLVIII.

CONCLUSION.

In reviewing the preceding pages the most striking fact that presents itself for consideration is the great stride made by the world's iron and steel industries in the last hundred years. In 1788 there were only 85 blast furnaces in Great Britain, most of which were small, and their total production was only 68,300 tons of pig iron. In 1882 Great Britain had 929 furnaces, many of which were very large, and their production was 8,586,680 tons. A hundred years ago there were no railroads in the world for the transportation of freight and passengers. Iron ships were unknown, and all of the iron bridges in the world could be counted on the fingers of one hand. Without railroads and their cars and locomotives, and without iron ships and iron bridges, the world needed but little iron. Steel was still less a necessity, and such small quantities of it as were made were mainly used in the manufacture of swords and of tools with cutting edges. It was, however, at the beginning of the railroad era, about the close of the first quarter of the present century, that the first marked increase in the use of iron in modern times took place. This was about sixty years ago. The invention of the steam engine made the railroad era possible.

The great progress made by the world's iron and steel industries in the last hundred years is as marked in the improvement of the processes of manufacture as in the increased demand for iron and steel products. A hundred years ago all bar iron was laboriously shaped under the tilt-hammer and the trip-hammer; none of it was rolled. Nor was iron of any kind refined at that time in the puddling furnace; it was all refined in forges, and much of it was made in primitive bloomary forges directly from the ore. Cort had just perfected the rolling mill and the puddling furnace. Only a few years ago a prejudice still existed in favor of hammered bar iron. Nearly all of the blast furnaces of a hundred years ago were blown with leather or wooden bellows by water-power,

and the fuel used in them was chiefly charcoal. Steam-power, cast-iron blowing cylinders, and the use of bituminous coal had just been introduced abroad, but not in this country. Sixty years ago heated air had not been used in the blowing of blast furnaces, and fifty years ago anthracite coal had not been used in them, except experimentally. Thirty years ago the Bessemer process for the manufacture of steel had not been heard of, and the open-hearth process for the manufacture of steel had not been made a practical success. Thirty years ago the regenerative gas furnace had not been invented. The nineteenth century has been the most prolific of all the centuries in inventions which have improved the methods of manufacturing iron and steel, and which have facilitated their production in large quantities.

The next most important fact that is presented in the preceding chapters is the astonishing progress which the iron and steel industries of the United States have made within the last twenty years. During this period we have not only utilized all cotemporaneous improvements in the manufacture of iron and steel, but we have shown a special aptitude, or genius, for the use of such improvements as render possible the production of iron and steel in large quantities. Enterprising and progressive as the people of this country have always been in the manufacture of iron and steel, they have shown in the last twenty years that they have in all respects been fully alive to the iron and steel requirements of our surprising national development. If we had not applied immense blowing engines and the best hot-blast stoves to our blast furnaces our present large production of pig iron would have been impossible. If we had not built numerous large rolling mills we could not have had a sufficient supply of plate iron for locomotive and other boilers, and for the hulls of iron ships, nor for oil tanks, nails and spikes, and other important uses; nor of sheet iron for stoves, the coverings for locomotives, and for domestic utensils; nor of tee, angle, and channel iron for bridge-building and general construction purposes; nor of iron rails for our railroads; nor of bar iron and rod iron for a thousand uses. If we had not promptly introduced the Bessemer process the railroads of the country could not have been supplied with steel rails, and without the

seven million tons of American steel rails that have been laid down in the past seventeen years our leading railroads could not have carried their vast tonnage of agricultural and other products, for iron rails could not have endured the wear of this tonnage. If we had not established the manufacture of crucible steel and introduced the open-hearth process there would have been a scarcity of steel in this country for the manufacture of agricultural implements, springs for railroad passenger cars, and springs and tires for locomotives. Foreign countries could not in late years have supplied our extraordinary wants for pig iron, rolled iron, iron and steel rails, and crucible and open-hearth steel, for, if there were no other reasons, the naturally conservative character of their people would have prevented them from realizing the magnitude of those wants. If our iron and steel industries had not been developed in the past twenty years as they have been it is clear that our railroad system could not have been so wonderfully extended and strengthened, and without this extension of our railroads we could not have produced our large annual surplus of agricultural products for exportation, nor kept the price of these products to our own people within reasonable limits; nor could our population have been so largely increased by immigration as it has been.

We can not fully comprehend the marvelous nature of the changes which have taken place in the iron and steel industries of this country in recent years unless we compare the early history of those industries with their present development.

In Alexander Hamilton's celebrated *Report on the Subject of Manufactures*, presented to Congress on the 5th of December, 1791, just ninety-three years ago, it was stated with evident satisfaction that "the United States already in a great measure supply themselves with nails and spikes," so undeveloped and primitive was our iron industry at that time. In the same report it was stated that in the year which ended on the 30th of September, 1790, our imports of nails amounted to 1,800,000 pounds. We did not even make our own nails less than a hundred years ago. In 1790 Morse's *Geography* claimed, in a description of New Jersey, that "in the whole State it is supposed there is yearly made about 1,200 tons of bar

iron, 1,200 ditto of pigs, and 80 of nail rods," and in 1802 it was boastingly declared in a memorial to Congress that there were then 150 forges in New Jersey, "which at a moderate calculation would produce twenty tons of bar iron each annually, amounting to 3,000 tons." In 1884 there were several rolling mills in New Jersey and over one hundred in the United States each of which could produce much more bar iron in three months than all of the 150 forges of New Jersey could produce in a year.

Fifty years ago the American blast furnace that would make four tons of pig iron in a day, or 28 tons in a week, was doing good work. We had virtually made no progress in our blast-furnace practice since colonial days. In 1831 it was publicly proclaimed with some exultation that "one furnace erected in Pennsylvania in 1830 will in 1831 make 1,100 tons of pig iron." But, as George Asmus has pleasantly said, "a time came when men were no longer satisfied with these little smelting-pots, into which a gentle stream of air was blown through one nozzle, which received its scanty supply from a leather bag, squeezed by some tired water-wheel." After 1840 our blast-furnace practice gradually improved, but it was not until about 1850 that any furnace in the country could produce 150 tons of pig iron in a week, and not until 1865 that this product had ceased to excite surprise. Ten years later, in 1875, we had several furnaces each of which could make 700 tons of pig iron in a week; in 1880 we had several each of which could make 1,000 tons in a week; and in 1881 we had one furnace which made 224 tons in a day, 1,357 tons in a week, and 5,598 tons in a month.

In 1810 we produced 53,908 gross tons of pig iron and cast iron; in 1840 we produced 286,903 tons; in 1860 we produced 821,223 tons; in 1880 we produced 3,835,191 tons; and in 1882 we produced 4,623,323 tons.

In his *Twenty Years of Congress* Mr. Blaine says that in the First Congress, in 1789, Mr. Clymer, of Pennsylvania, asked for a protective duty on steel, stating that a furnace in Philadelphia "had produced 300 tons in two years, and with a little encouragement would supply enough for the consumption of the whole Union." In 1810, seventy-four years ago, we produced only 917 tons of steel, none of which was crucible steel.

In 1831, fifty-three years ago, we produced only 2,000 tons of steel, probably not one pound of which was crucible steel, all being blister steel. So humble were our attainments as steel-makers in 1831 that we considered it a cause of congratulation that "American competition had excluded the British common blister steel altogether." In 1854 Overman declared that "the United States are at present, and will be for some time to come, dependent upon other countries for steel." He added that "in Pittsburgh attempts have been made to manufacture steel, but we doubt whether an article of good quality can ever be produced in that region." In 1882 we had virtually ceased to make even the best blister steel for the market, better steel having taken its place, and in that year we produced 1,736,692 gross tons of steel of all kinds, 75,972 tons of which were crucible steel. Our production of Bessemer steel and Bessemer steel rails in 1880 was larger than that of Great Britain, and in 1881, 1882, and 1883 our production of Bessemer steel rails continued to be larger.

It was not until 1844 that we commenced to roll any other kind of rails than strap rails for our railroads, and not even in that year were we prepared to roll a single ton of T rails. In 1847 we rolled 40,966 gross tons of rails; in 1849 the production fell to 21,712 tons; in 1854 it increased to 96,443 tons; and in 1855 it was hoped by the officers of The American Iron Association that it would amount to 135,000 tons, but this hope was not quite realized. In 1880 we produced 1,305,212 gross tons of rails, nearly two-thirds of which were steel rails. In 1881 we increased our production of rails to 1,646,518 gross tons, nearly three-fourths of which were steel rails. In 1882 and 1883 the proportion of steel rails to iron rails produced was much greater, but in neither year was the aggregate production quite as great as in 1881.

Although this country can not produce iron and steel as cheaply as European countries which possess the advantages of cheap labor and proximity of raw materials, it is not excelled by any other country in the skill which it displays or the mechanical and scientific economies which it practices in any branch of their manufacture, while in certain leading branches it has displayed superior skill and shown superior aptitude for economical improvements. Our blast-furnace

practice is the best in the world, and it is so chiefly because we use powerful blowing engines and the best hot-blast stoves, possess good fuel, and carefully select our ores. The excellent quality of our pig iron is universally conceded. Our Bessemer-steel practice is also the best in the world. We produce much more Bessemer steel and roll more Bessemer steel rails in a given time by a given amount of machinery, technically termed a plant, than any of our European rivals. No controversy concerning the relative wearing qualities of European and American steel rails now exists, and no controversy concerning the quality of American Bessemer steel itself ever has existed. We experience no difficulty in the manufacture of open-hearth steel in the Siemens-Martin or Pernot furnace, and our steel which is thus produced is rapidly coming into general use side by side with crucible steel. In the manufacture of crucible steel our achievements are in the highest degree creditable. In only one respect can it be said that in its manufacture we fall behind any other country; we have not paid that attention to the production of fine cutlery steel which Great Britain has done. This is, however, wholly due to commercial and not to mechanical reasons. American crucible steel is now used without prejudice in the manufacture of all kinds of tools, and in the manufacture of carriage springs and many other articles for which the best kinds of steel are required. In the quantity of open-hearth and crucible steel produced in a given time by a given plant we are certainly abreast of all rivals. The largest crucible steel works in the world are those of Park, Brother & Co., at Pittsburgh, Pennsylvania. Our rolling-mill practice is fully equal to the best in Europe, except in the rolling of heavy armor plates, for which there has been but little demand and in the production of which we have consequently had but little experience. The quality of our rolled iron, including bar iron, plate iron, sheet iron, iron hoops, and iron rails, is uniformly superior to that of foreign rolled iron. In the production of heavy forgings and castings, as well as all lighter products of the foundry and machine shop, this country has shown all the skill of the most advanced iron-making countries in Europe. In the production of steel castings we have exhibited creditable skill and enterprise.

All of our leading iron and steel works, and indeed very many small works, are now supplied with systematic chemical investigations by their own chemists, who are often men of eminence in their profession. The managers of our blast furnaces, rolling mills, and steel works are themselves frequently well-educated chemists, metallurgists, geologists, or mechanical engineers, and sometimes all of these combined. Our rapid progress in increasing our production of iron and steel is not merely the result of good fortune, or favorable legislation, or the possession of unlimited natural resources, but is largely due to the possession of accurate technical knowledge by our manufacturers and by those who are in charge of their works, combined with the characteristic American energy which all the world has learned to respect and admire. The "rule of thumb" no longer governs the operations of the iron and steel works of this country.

What wonderful changes have taken place since those "good old colony times" and the early days of the new republic, when our forefathers needed only a little iron, and what little they required was made by slow and simple methods!

A feature of our iron and steel industries which has attended their marvelous productiveness in late years is the aggregation of a number of large producing establishments in districts, or "centres," in lieu of the earlier practice of erecting small furnaces and forges wherever sufficient water-power, iron ore, and charcoal could be obtained. This tendency to concentration is, it is true, not confined to our iron and steel industries, but it is to-day one of the most powerful elements that influence their development. It had its beginning with the commencement of our distinctive rolling-mill era, about 1830, but it received a powerful impetus with the establishment of our Bessemer-steel industry within the last twenty years. In colonial days and long after the Revolution our iron-making and steel-making establishments belonged to the class of manufacturing enterprises described by Zachariah Allen, in his *Science of Mechanics*, in 1829. "The manufacturing operations in the United States are all carried on in little hamlets, which often appear to spring up in the bosom of some forest, gathered around the waterfall that serves to turn the mill-wheel. These villages are scattered

over a vast extent of country, from Indiana to the Atlantic, and from Maine to North Carolina, instead of being collected together, as they are in England, in great manufacturing districts." While these primitive and picturesque but unproductive methods could not forever continue, it is greatly to be regretted that our manufactures of iron and steel and other staple products could not have grown to their present useful and necessary proportions unattended by the evils which usually accompany the collection of large manufacturing populations in small areas.

Upon the future prospects of our iron and steel industries it is unnecessary for us to dwell. Our resources for the increased production of iron and steel for an indefinite period are ample, and all other essential conditions of continued growth are within our grasp. We are to-day the second iron-making and steel-making country in the world. In a little while we shall surpass even Great Britain in the production of steel of all kinds, and we are destined eventually to surpass her in the production of pig iron. We already consume more iron and steel than any other country. These conditions and results are certainly gratifying to our national pride. They mark wonderful industrial achievements by a young nation in a space of time so brief that we may almost say it dates from yesterday. They are also prophetic of other and still greater achievements. If it be true, as it is recorded in the second chapter of Daniel, that "iron breaketh in pieces and subdueth all things," the country which produces and consumes the most iron and steel must take the first rank in extending and influencing the world's civilization.

Meanwhile the fact is worthy of notice that the saying of Bishop Berkeley, "westward the course of empire takes its way," has already received a new interpretation, for the iron industry, the source and badge of material power, which had its beginning in Asia, and afterwards passed successively to the countries along the Mediterranean, upon the Rhine, and in the north and west of Europe, and thence crossed the Atlantic ocean, now finds a home in the shadows of the Rocky mountains and by the Golden Gate of the Pacific. It has made the circuit of the world.

GENERAL INDEX.

PERSONAL INDEX.

[This index includes the names of only a few writers who have been quoted, and does not include the names of persons of antiquity. The names of such writers as appear in the index are given for special reasons.]